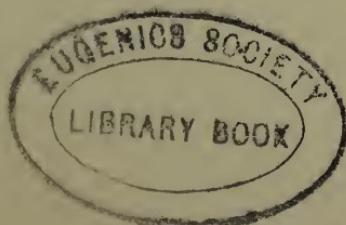




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To Major and Mrs. Leonard Darwin,
from Harry and Percy Loughborough



THE LIVING PAST



Courtesy of Dr. Chester Stock.

Footprints of an elephant exposed through excavation of a tunnel in the solid rock, Carson City, Nevada.

THE LIVING PAST

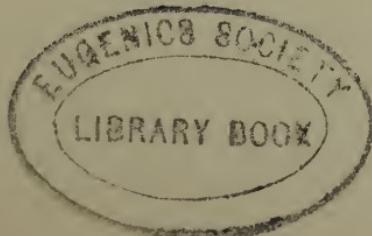
BY

JOHN C. MERRIAM

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INTRODUCTION

THE materials in this small volume are brought together with the purpose of directing attention to the meaning of the history of life. In considering what might have value from the point of view of the general reader, it is believed especially important to indicate some of the elements of human interest, and to make an effort to open the way for appreciation of the realities upon which the story rests.

In presenting this discussion it is realized that no mere printed statement can take the place of real things in nature. We may define natural features in terms or formulæ which conform to our standards, or we can describe the impression which they make upon us. Both methods may fail to give adequate understanding of their character, but, next to contact with the thing itself, the ap-

INTRODUCTION

proach by way of human experience has advantage. It appears desirable to see the elements which form the picture of history in the light of their appeal to those who know them intimately. Interest in the subject is assumed to be more important than organized information without adequate appreciation of its significance.

The history of life as visualized in this discussion is that aspect of the story concerned especially with changes and development through time, as contrasted with physiology, variation, distribution, and the many other phases of the great life complex as the biologist presents it. In the geological record, from which this history is read, one sees time and change in operation as in no other phase of knowledge. Inevitably in their contemplation inquiry arises as to the element of continuity through these events in history, and regarding the nature and trend of the movements represented.

INTRODUCTION

The chapters of this book are mainly episodes selected because of their touch with especially significant aspects of the problem of life history. It is not assumed that they will answer the many questions which might arise through their examination. If through the medium of these incidents the interest of the reader turns even in small measure toward consideration of the creation story as something which lives, the object of the work will have been attained.

THE LIVING PAST

CHAPTER I

THE MEANING OF A FRAGMENT

CHAPTER I

THE MEANING OF A FRAGMENT

THE story of life as it comes to us through the ages must in many cases be built upon fragments. This does not signify that it is therefore untrustworthy. Nor should it be assumed that it is always fragmentary. A clear understanding of the record requires appreciation of the nature of the evidence, especially if it rest upon interpretation of limited information. The following incidents in the course of a search for knowledge of ancient life in the caves of California illustrate conclusions which seem inevitable though based on scanty materials.

It was a part of the programme in this investigation to examine every suggestion that might lead to discovery of caverns in which remains of ancient life could be entombed. In searching for new clews, information was

obtained from Wintun Indian workmen regarding a cave long known because of reputed magic qualities of a pool in one of the larger chambers. Though the story came to us repeatedly, it was always in the same form: of a cave with a magic pool called in the Indian language, "Samwel," and that it was visited on account of the potency of its water in bringing good fortune. Always it concluded with an account of three maidens who failed to obtain good luck at the pool, and were told by a very aged woman of other water with stronger magic. A second pool was said to lie in a remote chamber, and to escape discovery excepting for the most adventurous. In the course of a long search for this more powerful charm the three maidens came to a pit with sloping borders. As they approached the entrance, one slipped on the moist rock. The others tried to save her, but she fell screaming into the darkness. They heard her "strike and strike again, and all

THE MEANING OF A FRAGMENT

was still." A rescue party was unable to reach the bottom of the well and efforts to find the maiden were abandoned.

The story of the cave of "Samwel" seemed to present the possibility of a cavern of considerable magnitude, in some part of which remains of ancient life might be discovered. Plans were therefore made to visit the locality. Considering that it lay in a wild, unsettled region, there was surprisingly little difficulty in locating the entrance of the cave. About sixteen miles above the mouth of the McCloud River an extensive series of galleries was found opening on the face of a limestone bluff three hundred and thirty-five feet above the river. Nor was there difficulty in finding a pool located in the third chamber. Whether or no its waters gave us good fortune, it is true that we succeeded also in the real objective of our search. On the floor of the cavern there were ancient deposits containing numerous bones and teeth represent-

ing elephant, horse, and other animals of California from a period probably antedating the present by many tens of thousands of years.

The second pool and the deep pit we did not find. Three expeditions failed in search for the well, and in the attempt to verify the story that had led us to this cave. Neither fascination of following the lead of a legendary description nor lure of unexplored regions could bring success. In the third attempt we made heroic efforts, crawled through passageways so narrow and tortuous as to seem impassable, and entered chambers apparently never before visited by white men; but without obtaining evidence indicating that the legend was based on fact. After the last trial the exploring party returned to camp, where excavations were under way at Potter Creek Cave near the mouth of the McCloud. Mr. Furlong, one of the members of the staff, remained at Samwel Cave to investi-

gate the fossil deposits discovered in chambers near the pool.

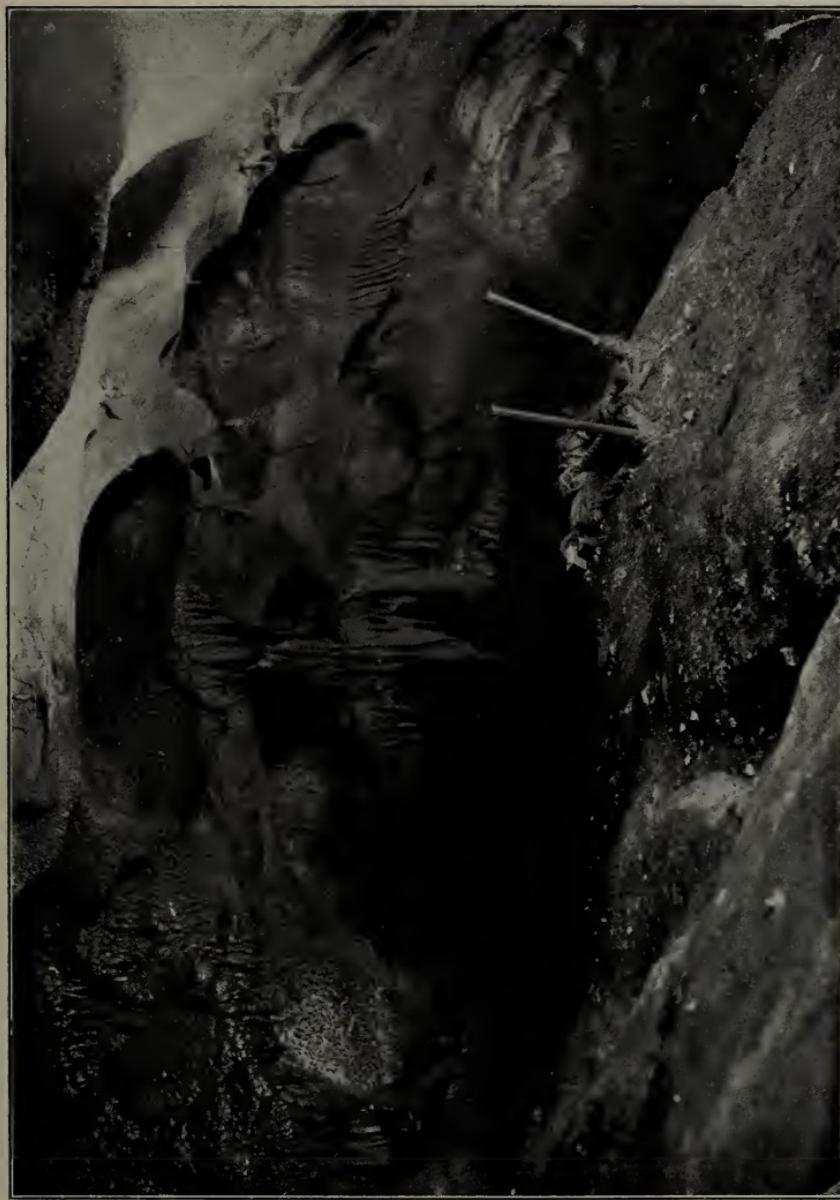
On the day following our return, a message was received from Furlong stating that he had found the deep pit, and requesting that I return as early as possible with all the rope-ladder and rope available. The next afternoon saw me at Samwel Cave camp with a pack-horse carrying fifty feet of rope-ladder and all the loose ends of rope to be obtained.

Furlong stated that on entering the cavern shortly after our departure he had noticed a narrow ledge along the wall of the second chamber. On following this shelf he discovered a series of galleries not seen in earlier exploration. At the end of these passageways was a pit with sloping borders. Rough measurement indicated a depth of approximately ninety feet. After transmitting word to me by a roundabout route, Furlong had returned to the cave and begun preparations for our descent. In the rock near the edge of the well

he made two deep holes so placed that the steel drills standing in the floor could give firm support to a ladder.

We spent the evening and the next morning in constructing an additional fifty feet of ladder from pieces of rope and such short sticks of wood as could be found. It was then something of a burden to transport this equipment to the edge of the pit. The ladder was firmly fastened. A few pieces of burning paper were dropped into the well to make certain that the air was safe for breathing. Then we drew straws for choice as to order of descent. Furlong's straw was the longer and he elected to go first.

As he descended, Furlong described the cavern opening to the light of his candle.— “It widens as I go down from a diameter of ten feet at the top to a great chamber below. And here as the ladder begins to hang free of the wall is a sharp projecting spine of rock that thrusts itself between the ropes and



From a photograph by the author.

PLATE 1. Entrance to the pit into which the Indian maiden fell.

THE MEANING OF A FRAGMENT

makes climbing difficult." Then after a longer wait, during which he moved carefully over the rickety lower fifty feet of odds and ends of rope and scraps of wood, the hobnails of his heavy shoes could be heard grating on the stone floor. It was a critical moment, waiting to learn whether the maiden whose tragic story had led us to this adventure was a reality or only the product of fertile imagination. Suddenly, with a voice raised by excitement, Furlong called up: "There's a mountain lion at the foot of the ladder." The swift train of thought in the ensuing moment I often recall, and the various possibilities that presented themselves. To go a little less than one hundred feet down an imperfectly constructed rope-ladder to help a man without weapons fighting a puma offered little hope of real assistance. If the lion should win, would it attempt to climb the ladder? Before any plan could be framed that seemed to have value under the special circumstances, Fur-

long shouted: "It is a fossil mountain lion embedded in the cave floor." Then, almost without pause, and with intonation indicating that he could hardly believe his eyes, came the words: "And here on the floor below the opening is the skeleton of the Indian maiden."

As quickly as difficulties of descent would permit I climbed over the edge, and down past the sharp spine of rock that thrust itself against the ladder. The well widened to a great chamber in which our unsteady ropes hung clear. Swinging free at the bottom I almost stepped on the skull of the mountain lion. A few feet beyond, Furlong was bending over a delicate human skeleton that lay huddled in a dark heap. The body had not moved from the spot where the girl crashed against the solid stone immediately under the opening. Only the bones and a film of black mould remained. Here and there a beginning crystal of stalagmite gleamed in the dark covering, but the lapse of time had not



From a photograph by the author.

PLATE 2. Skeleton of Indian maiden in original position on floor, Cave of the Magic Pool.

THE MEANING OF A FRAGMENT

been great enough to allow the lime deposited from dripping water to form a complete shroud.

This was the end of the trail we had followed so long. Was it also the end of the trail the maiden sought to follow? Could it be that in the tragedy which terminated her search she had found the pool of greater magic? As we asked this question our candles were held higher, and for the first time we looked about the cavern.

A portion of the bottom of this huge chimney was covered by masses of rock with lime incrustation. The broad floor was partly incrusted with sparkling stalagmite. The lowest area carried a layer of soft, brownish clay.

Scattered about, wherever we looked, were skulls and parts of skeletons of many animals, some so deeply covered with lime as almost to merge with the floor. The mountain lion at the foot of the ladder was heavily encased and cemented in the rock. Near the skeleton of the maiden was a large skull with grace-

fully curving horns. No head like it had been known to man before. Close by lay another creature with wide-sweeping, oxlike horns—a type of animal then seen for the first time. Across the cave was a perfect skull of a bear, incrusted and cemented to the floor. No human had known this type alive or dead. Spread before us was a veritable museum of ancient life, including also deer, squirrel, porcupine, raccoon, fox, rabbit, and many others. We wandered about the cavern attracted by each new treasure, but soon exhausted the means of expression that seemed adequate for this experience.

The remains which we saw on the cave floor belonged to a grouping of animals not previously known. They represented a stage in ancient life of America long antedating the fauna now ranging over mountains and valleys of northern California. Shut off from the outside world, in this chamber we stood as it were in the immediate presence of a remnant



From photographs by the author, much reduced in reproduction.

PLATE 3. Skulls from floor, Cave of the Magic Pool. *Above*, an extinct goat-like animal.
Below, the extinct bear as repaired by Mr. Furlong.

of the past that through protection of these walls had remained to give its testimony.

The scant traces of original organic material covering the skeleton of the Indian maiden, and the incomplete lime incrustation upon the bones, indicated that entrance of the girl into the cave had been at a very recent period compared with that of the strange creatures among whose heavily incrusted skeletons she had come to rest.

Nowhere in the chamber was there evidence of standing water, unless it once occupied the area covered by soft clay. The maiden who led us on the trail of the pool of greater magic failed in her special mission, but had marked the way to knowledge of mysteries as great as those she sought to fathom.

For hours we studied the cave and its treasures. Then, seeing that it was late, we made preparations for return to camp. In the course of the afternoon Furlong had been charged

with the study of this cave and its many fascinating problems. As we were leaving he remembered that C. Hart Merriam, the great authority on bears, was in our camp at Potter Creek, and that his judgment might be had on the characters of the bear whose skeleton was frozen in the cave floor. The skull was straightway pried loose, wrapped in my corduroy coat, and fastened to the foot of the ladder.

Weary with the long day's work, we made our way carefully to the galleries above. At the edge of the pit we drew up the ladder with the bear skull attached. It was heavy. We pulled together. Then Furlong held fast while I laid back the folds of the ladder as they came over the edge. After seemingly interminable hauling, the last rung appeared with the cord fastening the skull. The last fold was lifted back. When I turned again Furlong stood with one hand reaching over the well, holding the end of the ladder, but

THE MEANING OF A FRAGMENT

rigid as if turned to stone. The corduroy coat and the bear skull were gone. Suddenly there was a crash. The cord which tied the package to the ladder had parted just as the end was lifted over the rim. Mr. Furlong prefers that discussion of what was said in the ensuing moments be omitted. He insisted on lowering the ladder, and descended to learn the fate of his new bear.

The skull was spattered over practically the whole floor, but with unbelievable care Furlong gathered up every piece. No fragment escaped; all were wrapped in a new bundle and once more the bear journeyed to the top of the ladder. When, many weeks later, the remains reached the laboratory, he fitted them together with such skill that the mounted specimen as we see it now appears almost without flaw.

The absorbing experiences of the day, pieced out with the escape of the bear and its recovery, made us lose the count of hours,

and arrival at the cave entrance did not diminish immediate usefulness of our candles, as it was night. We stumbled into camp conscious mainly of an overpowering need of sleep. Furlong found a pan of rice and a can of tomatoes cached in the ice-cold water of the McCloud. They sufficed to meet a hunger largely overwhelmed by weariness. Lying back on my sleeping canvas, for a moment I was conscious of the piercing brilliance of starlight, and a babel of muffled voices from the river—and then the bright light of morning wakened us.

Many days were consumed in preliminary study of the deep well and its treasures. Furlong then began systematic gathering of the abundant remains of ancient life on the floor. With this work under way the remainder of my time was spent in exploring nooks and crannies for further evidence regarding the origin and mode of entrance of the creatures whose bones were found in this chamber. It

seemed inconceivable that the large animals here could have found their way in through the long dark galleries leading to the small aperture above, nor was there piling up of skeletons immediately below the mouth of the pit such as would have occurred had the bodies fallen in. There seemed good reason for assuming that at some early time there had been a lower passageway through which bears and pumas, and the creatures upon which they preyed, had reached the cavern—an opening that later changes had closed and sealed.

The search led finally to a narrow space behind a number of large rock masses on the extreme margin of the chamber. Among the loose blocks were numerous parts of skeletons. There were porcupine, gray fox, a tooth of an extinct ground-sloth whose relatives were found in Texas and South America, and then among the bones appeared a portion of a human tooth. Instantly this fragment raised

question whether man had been present at the time the ground-sloth and other animals now extinct inhabited this region. Upon this fragment centred the critical inquiry of our whole programme of research.

There was at least one other possibility. With the specimen in my pocket I climbed over the rocks toward the skeleton of the Indian maiden. As I advanced my mind focussed on the chance of proof that this particular portion of a tooth from a remote part of the cave belonged to the remains on the floor below the entrance. If the irregularly fractured end of this fragment should fit with perfect smoothness upon a roughly broken tooth in the skeleton of the Indian girl, there would be no need of further answer to questions concerning presence of the human tooth among the relics of these ancient animals. It would be clear that the individual represented by the fragment was a comparatively recent arrival, and not a contemporary of the

THE MEANING OF A FRAGMENT

strange extinct creatures whose skeletons were here seen for the first time.

With the tooth in hand, the skull was turned till the teeth were all in view. A portion of one was missing. The broken end of the fragment was brought into contact with the fractured tooth in the skull. The irregular ends touched and grated as their unevennesses failed to match. A slight twist and the surfaces seemed to melt together. No smallest roughness held them apart. There could be no doubt that they belonged together.

As the fragment fitted to its place in this skeleton there flashed into mind the ending of the Wintun story of the maiden who sought the pool of stronger magic. "She fell and struck, and struck again and all was still."—High up on the wall was the sharp spine of rock projecting below the mouth of the pit and, looking up, as if the drama were being re-enacted, I seemed to see the falling figure strike in mid-air on that protruding

point, a fragment of tooth flew wide across the well—the body “struck again” upon the floor, and “all was still.”

To the Wintuns in this region we gave the story of our search for the well and the second pool. In turn, they told us something of the family of the maiden who perished in the pit between one and two hundred years before our coming. They asked to take the skeleton, and as much of it as was carried up the rickety ladder was entombed again with ceremony where the crystal waters of Nosone Creek join the McCloud.

Summer ended before work in the cave of the Indian maiden was completed. In the meantime we had tried by many methods to locate the suspected ancient entrance through which the numerous animals on the floor could have entered. A stalagmite-covered slope next the wall suggested a stream of earth coming from a passageway which it

might have filled. A cut was made. Below the thick lime incrustation were earth and gravel. The heap led to an opening in the solid wall, and then upward through a chute penetrating the limestone in which the cave had been formed. As work proceeded there was grave danger from caving, as the earth was above us, and means were not available for adequate protection. Not wishing to risk serious accident, further examination of this gallery was postponed to another season.

A year later, during the last stages of excavation, we made calculations as to the nearest point on the outer wall, hoping that by this means an ancient outer entrance might be discovered. A shaft was sunk at the place located. At eleven feet it entered gravel through which oozed a strong draft of cold air. Following the gravel layer horizontally the draft increased. Suddenly gravel and earth gave way and we were digging into a small buried chamber. The thrill experi-

enced was of that peculiar type that comes only in facing the mystery of a hidden room, perhaps shut off for ages from the outer world. What secrets of the past might it hold?

The cavity we had entered was a small chamber closed on every side. It gave no evidence of a passage extending into the mountain or toward the cave in which our excavations had been conducted.

Boynton, the athlete of the party, volunteered to climb back to the main entrance and down to the cave of the maiden to discover whether signals could be heard through the intervening rock. It seemed only a moment after his leaving that a sharp tap came from a point near the inner wall of the hidden chamber. It was followed by other rappings, each seeming nearer than the last. The pounding stopped, and there was a rasping suspiciously like scraping of heavy shoes dragging behind a man crawling through the

THE MEANING OF A FRAGMENT

narrow opening between the cave of the maiden and the lateral chute into which we had dug in the previous year. Furlong was remarking that the sound came from a point only a few feet distant when, with unbelievable distinctness, we heard Boynton say: "For heaven's sake step easy or you'll come through." Without stopping to reply a shovel was seized and stabbed sharply into the earth at my feet. The floor gave perceptibly. A few more strokes and we saw the light of Boynton's candle for an instant before a rush of cold air extinguished his light and ours. A moment later the wind died down. The candles were relighted. The opening was widened, and the smiling face of Boynton appeared as he climbed through.

Scant eighteen inches of earth and gravel had separated the highest point of excavation in the previous summer from the floor of the hidden chamber. The chute, the hidden chamber, and the shallow outer grotto partly

filled with earth in which our shaft was sunk, formed a passageway reaching through the limestone cliff to the cave of the maiden. When, later, the earth was partly cleared the opening showed itself sufficiently large and easy of travel for ready use of the animals discovered in the cave. There could be no doubt that one of the mysteries of the cavern was solved. A large part, if not all, of the creatures we found had entered by this route. The mountain lion at the foot of the ladder, like the unfortunate Indian girl, may have lost its footing at the mouth of the pit and fallen to the floor below. Other animals possibly entered by passages as yet unknown, but the wide and relatively direct way we had just followed was clearly the principal means of entrance for the ancient population.

How long this buried entrance had been closed, and the precise time at which it was open, we may never know in terms of years and dates such as are used in description of



From a photograph by the author.

PLATE 4. Mr. Boynton enters the Hidden Chamber by way of the Cave of the Magic Pool. Outside entrance seen to the left.

THE MEANING OF A FRAGMENT

events of recent human history. In the period when the creatures found resting on the cave floor were moving back and forth through the ancient entrance, the face of the land and the life roaming over it differed from what we see to-day. At the later stage when the entrance was blocked the landscape approached more closely its present features. When the Indian maiden, clambering over the rocks to the upper cave, looked back toward the blue river for the last time, the early entrance was already lost to view behind a mask of débris.

Such are the outlines of a story that as yet we read only in part. Lured by the possibility of bringing to her use something of the mysterious power she saw everywhere in nature about her, the Indian girl opened the way to mysteries which the veil of time had seemed completely to protect. The fragment of a tooth that parted, when she "struck and struck again," brings before us in clear reality

THE LIVING PAST

the maiden in her strange adventuring, who joined the sleeping company of ages past, and led us to a place where we could have a fleeting vision of the world in other days.

CHAPTER II

POOLS THAT REFLECT THE PAST

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POOLS THAT REFLECT THE PAST

A DIARY written on the first Spanish expedition to California contains the description of a peculiar swamp of asphalt or of brea which was reported to flow like melted rock from underneath the earth. In a later stage of exploration the first transcontinental railway survey party found in the same region a locality where mineral pitch poured from the ground in great quantities and sometimes formed large pools or lakes. One spring was pictured as coming from a small opening around which the asphalt spread over a circular space about thirty feet in diameter.

This region of the black springs, known as Rancho La Brea, near the site of present-day Los Angeles, came in time to be operated by the owner as a source of asphaltum used for

roofing and paving. Chinese laborers dug the best parts of the deposit from the pools and cleansed it in large vats. The impurities were separated by heating the mass to a temperature at which the liquid asphalt could be poured into moulds, leaving a residue consisting of tree stems and bones. The trees were laid aside by the workmen for use as fire-wood. The bones were thrown on refuse heaps, which came ultimately to contain thousands upon thousands of fragments of skeletons representing many kinds of animals.

Major Hancock, the owner, was familiar with the way in which all manner of beasts and birds were caught and buried in the brea. He had seen squirrels, chickens, ducks, calves, and colts walk unsuspectingly upon the surface of the sticky mass, fall, and struggle until they were gradually ingulfed. It was a common experience to find cats, dogs, and coyotes lured by the struggle of animals thus



From a photograph, courtesy of Los Angeles Museum.

PLATE 5. Modern ground squirrel trapped in asphalt, Rancho La Brea.

trapped and themselves become victims of the pool. The considerable losses of fowls and stock from the ranch gave some indication of the extent to which remains of creatures buried in this way might accumulate in the course of years.

It was known to Major Hancock that many of the skeletons found in the pits which he excavated differed greatly from those of barnyard animals, and from the coyotes, squirrels, and other wild life in the valley. Some of the bones were too large to belong to any creature known to have lived in California, and the skulls of many birds and four-footed animals discovered were entirely different from those of all living things with which he was acquainted.

A naturalist from Boston, who visited Rancho La Brea, was asked to probe the mysteries of the asphalt. He found the innumerable skeletons in the pits to be largely those of animals no longer living anywhere

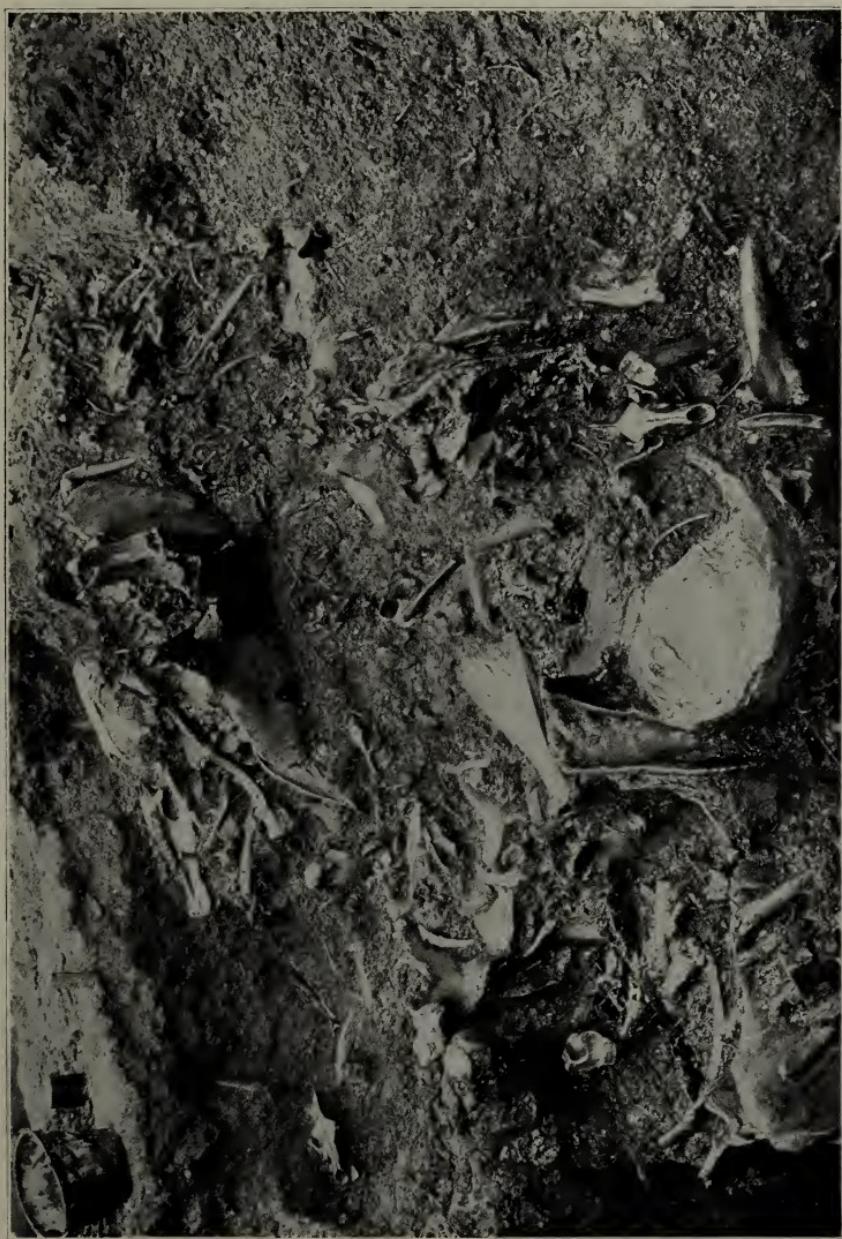
on the earth. A great scimitar-like tooth he described as that of a gigantic cat, similar to remains found only among the relics of ages long preceding historical times.

After the death of the owner, and the stoppage of work on the asphalt deposits, the explanation which the naturalist had given for the presence of bones in the brea seems to have been forgotten. Thirty years later a new series of investigations brought out again the fact that the asphalt pools were the tombs of a vast number of creatures that had inhabited this region at a period probably antedating the present by at least one hundred thousand years. The skeletons buried in the brea were shown to represent not only an immense number of individuals, but a great variety of creatures as well.

Among the animals recognized were such strange forms as the elephant and camel, together with extinct horses and bison. With these beasts, of which we know similar species

From a photograph by the author.

PLATE 6. Undisturbed fossil remains of extinct animals in asphalt deposit, Rancho La Brea.



living in other parts of the world to-day, there were mastodons, great ground-living sloths as large as rhinoceroses, gigantic bears differing from every living type, lions exceeding in size all other felines living or extinct, a multitude of cats with knife-like fangs, a huge extinct wolf probably the largest of his tribe, an eagle-like bird greater than the condor, and a multitude of other birds and beasts entirely strange—even to those most deeply learned in the animal life of the present world.

The discoveries at Rancho La Brea told one of the most remarkable known stories of the life of a past period, and naturally led to extended scientific investigations, involving excavation of the asphalt pools and reassembling of the skeletons unearthed. The results brought out a vast amount of material, which has been estimated at approximately 3,000,-000 bones.

In this multitude of specimens every detail

of structure is retained. The preservation of bones and teeth is not farther from perfection than in the remains of recently dead cattle bleaching near by. Not only is there perfect conservation of the material composing the skeletons, but with this is indubitable evidence of many aspects of use or action in the life of the individual animals represented. Cutting and tearing teeth of wolves and lions are seen worn down where they rubbed upon each other, or against the bones and softer tissues of the creatures upon which they preyed. Molars of bison, camels, horses, and elephants are grooved and scored by mastication of their great bulk of vegetable food. There are the bitten and broken bones of many birds, wolves, and tigers. In some of these, imperfect contacts led to healing in such manner as to leave crooked or twisted limbs. Abundant specimens show diseased tissues of many parts of the skeleton and teeth.—A wolf with a broken foot, and a



From a photograph, much reduced in reproduction, courtesy Los Angeles Museum.

PLATE 7. Skeleton of an extinct ground-sloth, Rancho La Brea.

sabre-tooth tiger with fractured and shortened arm, tell each a story for which conviction does not depend upon intricate logic or abstruse scientific theory.

One also looks intimately into the changing stages of life of these creatures from babyhood to old age. Lion and tiger cubs and baby wolves show every step in development of skeleton and dentition from the time when the milk teeth just began to appear, on through the many advances to complete replacement by permanent teeth, and into the years of decadence and senility.

Out of early excavations in the pool there came one day the skull of an ancient tiger with sabres broken and shattered to the roots. The ends of these teeth were worn and blunt, as also the front teeth opposing them in the lower jaw. Through long wear produced by biting upon its food in the form of other creatures on which it fed, the fractured blade of one great tooth had been cut down to a

smooth broad surface. Also shattered and splintered, the other sabre showed less wear on the broken end. This second tooth had maintained itself intact long after the other was broken. But at last it fractured in an unduly heavy or misdirected blow. Instead of carrying death through the swift, sharp strokes of its sabres, the habits of life of this animal were changed, as also in all probability the nature of its food. The tremendous roots of the sabre teeth were shrunken, and the bone around them had shrivelled. It was an old, emaciated, sunken-cheeked animal that left us this record of its last adventure, in which strength, and skill, and courage were inadequate.

In the multitude of individuals buried here the vast predominance of types that fed on flesh seems almost beyond belief in contrast to the smaller group of those which formed their prey. But to the flesh-eating animal these pools were continuously baited traps.



From a photograph, much reduced in reproduction, courtesy Los Angeles Museum.

PLATE 8. Extinct sabre-tooth tiger, Rancho La Brea.

Any creature captured and struggling in the tar was a lure. The young and inexperienced, the crippled and incompetent, and the aged ones with failing limbs, seem under the stress of hunger to have risked the effort to obtain a meal from prey that lay within their easy reach.

As the centuries passed, like a great procession streaming from surrounding hills and plains, the birds and beasts swept into the blackness of these pools. Here was gathered a multitude of witnesses, who through the "still lapse of ages" waited the time when in the unavoidable evidence of their reality they were to bring a living story of the past before us. They appear to-day not as formal revelation, but as clear evidence, which through this staying of the hand of destruction permits us to look into the living world of a past eon.

In the great numbers of kinds of beasts and birds entombed in the asphalt pools a

large percentage are of types no longer living on any part of the earth. Many of these have their nearest relations in the life of still earlier ages. Such are the sabre-tooth, mastodon, ground-sloth and others. The elephant, camel, and horse, have close relatives living to-day on other continents. With these two groups are other species, as the coyote and puma, the rodents, many birds, and plants like oak and cypress that have intimate resemblance to species at home in California to-day. If the whole group of animals and plants from these pools could stand before us, the assemblage would be that of a foreign age or land, but among them would be many friends of our out-of-doors to-day. Here we face the reality of another world of life shown in many strange phases, and yet the beginning of the present reaches back to overlap that early time.

CHAPTER III

THE STORY OF A LEAF

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It happens often that the greater things of nature, as in human life, are only imperfectly appreciated until in the light of a single circumstance suddenly they arise to overshadowing importance. So we read that when Elijah stood upon the mount before the Lord, it was not in the strong wind, nor yet in the earthquake or the fire, but through the "still small voice" that the Almighty was recognized.

On a recent journey to Columbia River Gorge I had the pleasure of revisiting a region familiar from many years of interest in the meaning of its history. As on other occasions, the bordering cliffs, with summits disappearing in mist and the river moving majestically below, made me see the canyon in

all its strength and beauty. In the geologists' language, I read again the record of ancient floods of lava piled up to build a mountain in which later the river cut this gorge. But it remained for a fragment of a leaf, fluttering from its burial place in the foundations of the valley wall, to give through compelling vividness of its own reality the clearest expression of this story of creation. The finding of the leaf continues always fresh in memory as one of those occasions when the past seems to open, and for the moment we look through to see the Builder at work.

It was on a stormy day in July that I passed through Columbia Gorge with a party of geologists engaged in study of the history of that fascinating region. Riding down over swinging curves of the highway we examined the rock formations which make the canyon rim. The summit was formed by edges of old lava flows. Below the lavas were thick layers of water-washed gravel and boul-

ders. Deeper in the gorge the gravels lay upon still greater lava flows, piled hundreds upon hundreds of feet to make the wall. Across the river these lava beds were seen extending widely under mountains and plains beyond.

As the panorama lengthened our wonder deepened. Rising two thousand feet around and above us were stony cliffs of what was once melted rock. Below, like a great ribbon-saw, the river was cutting its way with teeth of sand and gravel dragged upon its floor. We recognized the canyon as merely one stage in a process of shaping and moulding of the vast pile into which it had been cut.

Approaching the historic station of Bonneville, our party found the lower beds of lava along the highway resting upon a foundation of rocks that had formed the landscape over which these first flows were poured. This underlying formation consisted of layers of hardened sand, gravel, and mud. A mem-

ber of the party who had made special study of the region stated that at this point the rocks beneath the lava contained buried in them remains of plants that flourished here before the time of the first lava flows.

It was where the highway skirts a steep bluff, before bending round the curve at Tanner Creek, that search was made for the locality reported by the specialist in history of plants. The cliff rose almost perpendicularly from the pavement. Its irregular face was marked by widely spaced bands of stratification representing difference in materials. In the first large exposure bordering the road, a log of petrified wood projected from a rock which had once been the mud and sand that covered it. A few yards away the twisted stem of a dead tree of modern time hung over the cliff. The fringe of forest, draping the bluff above, was formed of fir, maple, willow, and dogwood. Near the fossil log a living alder clung to the face of the rock, and a sword-fern

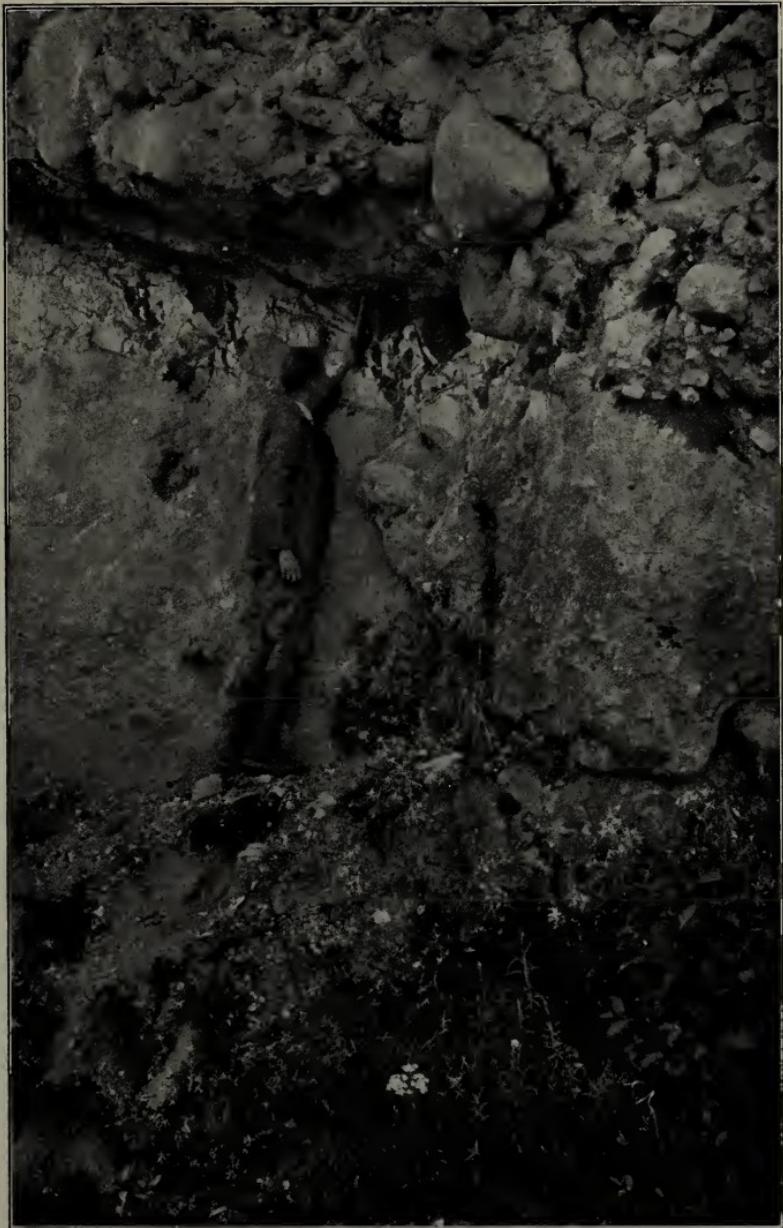
had fastened its roots in a softer stratum close by.

Rapid search revealed the locality reported to furnish remains of plants. A few strokes with a pick in the soft layer from which the sword-fern grew brought out fragments of rock covered with clean-cut impressions of leaves. There were maple, sweet gum, hickory, and oak, with numerous other kinds. The palæobotanist, who had spent many days collecting in this stratum, began to name the plants discovered. I interrupted to ask if he had obtained the Gingko, a beautiful tree originally known living only in groves about the temples of China and Japan, but found also as fossils at localities spread widely over the northern half of the world. "Yes, I have found it, but only rarely," was the reply. "Oh," said a student standing near, "I have just seen an impression of a leaf." He ran to the cliff and brought a small slab. On one edge was a narrow imprint showing clear

tracery of a leaf like a maiden-hair fern, but duplicated only by the Gingko.

When the print appeared my mind went back to a tree of this strange type planted in the court of the Cosmos Club in Washington. I remembered sitting in the yard at lunch on a warm summer day and pulling down a leaf as reminder of the quest I wished to see for wild Gingkos in primitive forests of Asia. I thought of the history of the tree as known to the palaeobotanist—for millions of years widely spread over the northern hemisphere, and now only a slender residue remaining protected in the sacred forests.

Still looking at the slab, but with my thoughts in Washington, in China, and in the world of past ages, my youngest son brought me back to Columbia Gorge by remarking that he saw the leaf itself still in the rock. "No," I replied. "It is only the impression that remains. In these formations the leaf decays and disappears. Not even a film



From a photograph by the author.

PLATE 9. Locality at which the fragment of a gingko leaf was found embedded in the rock, Columbia Gorge.

THE STORY OF A LEAF

of coal is left from the carbon which it originally contained." "But the leaf is there," he said. Then, to prove the truth of my statement, taking the specimen, I pulled apart the layers on which the impression was made, and as they separated, clinging to the print, we saw a brown fragment of a leaf with one edge lifted and moving in the wind. The structure was that of a Gingko, time-bronzed and shrivelled—but a leaf, and not merely the trace of its form upon the rock.

My eyes turned to the bluff from which the fragment came. Beyond the layers of sand and mud in which the leaf had been entombed, rose cliffs of lava, stepping up and up to the rim of the gorge. I looked across the chasm the river had cut, and then saw again the remnant of the Gingko fluttering in the breeze. Since last the wind had stirred this fragile thing, a mountain had piled itself upon it. Floods of melted rock had sealed it in. And then the river, sawing for ages

through the mass, had made easy its liberation by the hammer of a student seeking to know the truth about the past.

In careful wrappings the Gingko fragment from Columbia Gorge crossed the continent to tell still further details of its history through microscopic examination of its structure. At the laboratory in Washington it was lifted from the rock to which it adhered, and after careful preparation came to the table of the microscope. By its side lay a similar portion of a Gingko leaf from the tree in the courtyard of the Cosmos Club.

The expert first examined the modern leaf, noting the pattern of its cells. Then the ancient fragment took its place in the field of magnification. The lighter tint of the living leaf was replaced by brown of the specimen from beneath the lavas, but pattern of leaf and form of cell were as much alike as two closely related ferns or oaks of to-day.

As he moved it about under the micro-



From a photograph, slightly enlarged, by the author.

A living gingko tree, to the right behind the Daniel Webster Monument,
Washington, D. C.



From a photograph by Dr. R. W. Chaney.

PLATE 10. Impression of a gingko leaf from locality where the "fragment of a leaf" was found.

scope, the specialist ran his eye rapidly over the surface of the ancient leaf-blade. He had hoped to find all details of structure present, but the guard cells bordering the breathing pores were not to be seen. He ventured the suggestion that "perhaps after all this never was a living, growing thing, but only an accidental resemblance to a leaf, or an incomplete experiment in creation." "Possibly," I replied, "you are looking at the wrong side of the leaf." The fragment was reversed. A few quick shifts followed, as the object was moved across the field of vision. Suddenly there was close examination of something that caught his eye. He changed the focus, and then motioned me to his seat at the microscope.

Looking down on the illuminated leaf, I saw dotting its surface characteristic pairs of cells which guard the pores through which plants breathe. It was clear that in this specimen, as in the green Gingko fragment from

the living tree, these little mouths had opened and closed through the rounds of daily life for a season. And then on a late summer day, as a golden leaf with its work completed, it had whirled down to the stream that buried it.

For a moment the fragment faded from clear focus, as I remembered the leaf where it lay beneath the wall of the canyon in layers of rock that had been mud washed upon it ages before. And then the eye of my mind did what as yet no man-made instrument has accomplished. Through the assured reality of this leaf, as it was then and had been so long ago, a view was opened across the eons connecting present and past. In that sweep of vision it was not possible to avoid the panorama of history just as it had occurred. Glowing lavas crept out, flow on flow, through ages to build the mountain; and then a river began its work of fashioning the canyon.—Suddenly my friend inquired: Had I seen the guard-cells? “Yes, and also travelled

out across the continent, and back through time so far I might not guess the distance."

The cliffs in which the Gingko lay entombed in Columbia Gorge are included in Mount Hood National Forest. Some years ago a portion of the area was set aside by the Forest Service as Columbia Gorge Park. Within this region, by help of cards of description, the traveller is assisted in his effort to know the lessons of the place more intimately. When next you visit the gorge, approaching Tanner Creek on the highway from the west, you will find a simple marker on the cliff in which the Gingko leaf was found, and in which others still rest. At the foot of the wall you will see a Gingko tree planted from stock that grew about the temples of Japan. Its branches brush the rocks in which the ancient leaves are buried.

If you frequent the canyon, you will find that no matter how often you follow the highway from Portland to the Columbia, there

is always a thrill when the ridge above Crown Point is crossed and suddenly the gorge appears. It may be that to some this panorama expresses itself solely in terms of superficial form and beauty. Looking often over the valley, it has seemed to me that no one could view this picture without finding revealed something of that movement of creation of which it is the result. Commanding as are the features of external beauty, evidences of the process of making portrayed are of such significance that details of the spectacle must be recognized as only incidents in a moving panorama. To know the whole story takes nothing from appreciation of form and feature as they appear at the moment. This knowledge only extends our vision. We come to realization that the elements of grandeur comprised in bulk and static strength have their present values because they are residual demonstrations of power exerted in a great work of construction.

To-day we begin to see through all nature the movement of great forces involved in the process of creation. As this panorama opens we glory in our growing power of comprehension. Then on a rare occasion, in an unexpected region, there appears a new expression of reality far transcending that built upon previous experience and imagination.

This flash of understanding, with widening horizon, can come to each individual as veritable revelation. It may bring realization of unmeasured power bound in the atom, another universe beyond the stars, a new vista in the past, or an explanation of some baffling phase in human life.

We may stand often, as it were upon a mountain, with the elements spreading their power before us, and yet miss the gentler message that makes it possible to see behind the face of nature and read in some small part its deeper meaning. It was under such circumstances that a fragment of a leaf

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opened the doors upon a living past. There fire, earthquake, and the flowing power that cleft the mountain, each was seen to have its part in building order and beauty into the world in which our lot is cast.

CHAPTER IV

A LIVING LINK IN HISTORY

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A LIVING LINK IN HISTORY

AMONG the living redwood groves of the west, as in few places, one's thought turns irresistibly to focus on the meaning of the past in its relation to present and future. Considered in the setting of their history, these great trees open to us one of the most fascinating chapters in the story of life.

As you advance into these splendid forests, the arches of foliage narrow above you and shade deepens into twilight. Between close-set trunks you look through windows framed in shadow. Here and there behind these openings in a distant aisle faint touches of sun upon the shaft of a young tree bring out its red-brown glow. Like pillars of a temple, the giant columns space themselves with mutual support, producing unity and not mere symmetry. Ponderous strength, an almost

infinite variety in expression of light and shade and color, and a perspective with marvellously changing depth, compose a scene such as canvas has yet to receive.

But woven through this picture is an element which eludes the imagery of art. The sense of time makes itself felt as it can but rarely be experienced. While, through contrasts of their seemingly fantastic architecture, ancient castles may tell us of other ages, living trees like these connect us as by hand-touch with all the centuries they have known. The time they represent is not merely an unrelated, severed past; it is something upon which the present rests, and from which living currents still seem to move.

The mysterious influence of these groves arises not alone from magnitude, or from beauty of light filling deep spaces. It is as if in these trees the flow of years were held in eddies, and one could see together past and present. The element of time pervades the

forest with an influence more subtle than light, but that to the mind is not less real.

Within the belt of redwood forest in northern California is a place, near Calistoga, where in the solid rock forming commanding hills there lie remains of many massive trees differing little, if at all, from redwoods growing on slopes near by. They are now trees of stone, but in all details of form and structure, even to microscopic minutiae of the cells composing them, they are redwoods. In clay-like layers of the rock in which these trunks are buried, imprints of leaves appear such as are made by foliage of redwood trees along the muddy borders of streams to-day.

One imposing column, known as the "Monarch of the Forest," has been followed back by excavation, where its broken end projected from the hillside, until almost one hundred feet of its length are visible in a tunnel extending into the rock. The log, six to eight

feet in diameter, still lies embedded in its stony matrix. In the roof of the cavern, undisturbed strata of the material which buried it arch completely over this splendid pillar.

As I stood in the excavation looking out along the great tree, a tourist engaged me in conversation. Asked what impressed him most in viewing this specimen, he replied: "The fact that there can be no doubt of its having lain buried for ages in this rock which covers it. It surely was once a tree that stood up and faced the sun, and"—pointing with his foot to a deep hole in its side—"I suppose that birds and beasts of long ago nested in its trunk."

One stands outside the tunnel and looks over the hill above. The rock that forms the slope seems a huge bulk of material piled upon the trees beneath, but it is only the remnant of a greater mass that came largely from ancient volcanic eruptions—perhaps from the region of Mount St. Helena near by. The

thickness of ashes and mud which formed the original deposit we do not know, but since they hardened to consistency of stone the flow of streams has been for ages carving the face of this land into its present form.

Through all the time this shaping of the landscape was under way the prostrate "Monarch" lay in quiet deeper than that of the forest in which it once grew. The noise of battling elements and of warring creatures above did not reach it. Only now and then there came a trembling of rocks around it or the rumble of a swiftly passing earthquake, as the foundations of the hills were shaken by movement of the uneasy earth. And then the world of light returned, stream and wind flowed over it, living forests gathered round it, birds and beasts climbed again along its frame, and finally man came to see it—both as it is and as it was.

The redwoods existing to-day are surviv-

ing remnants of a splendid race that has been many millions of years in developing to its present majestic stature. They are rare examples of a group spread widely over the world through long periods, and of which just sufficient is carried over to the age of man to tell us the contribution it has made to life of the earth.

In northern California, where these forests reach their highest development, they extend over a country of deep valleys and bold hills or mountains rising to an elevation of several thousand feet. The features of the landscape are determined in part by variation in the geological formations from which they have been cut. A considerable portion of the area in which the finest redwoods grow is underlain by a series of sand and clay strata thousands of feet thick. Embedded in these hardened sands and muds are remains of animals and plants that lived in the region at the time the layers were be-

ing formed. Among these relics are the stems of redwoods.

At the little town of Garberville, where I spent many pleasant days in study of the country, strata of this formation at least a half-mile in thickness are exposed by the south fork of the Eel River. In places where the stream is cutting its bed in solid rock the section interprets itself so clearly that no one who sees can fail to understand.

I asked my friend Monroe, age eleven, whether he had ever found clam-shells or remains of other animals in the cliff where the river impinges on a high bluff near the town. He took me over the precipitous wall to a point where sea-shells were embedded in solid sandstone. Near by was a large fossil vertebra with stony matrix still clinging to it, and from the solid face of the rock above we dug a whale rib.

A short distance below us the swift stream washed over lime-cemented reefs of sand-

stone filled with perfectly preserved shells, including scallops, razor-clams, and many other kinds. These remnants of ancient deposits, with the remains they contain, once spread over the bed of the ocean. They had been heaved and bent until now their steeply tilted and eroded fragments stand high above the sea. On the slope near by stood a grove of redwoods, a surviving remnant of forests whose entombed remains lie in the hills upon which they grow.

As I stood once with a group of friends looking into a redwood forest, which we had come far to see, in swift panorama the history of these trees and of their surroundings as I knew them passed before me, stage after stage from the remote past.

The distant age of reptiles with its weird population, the dinosaurs and all their kin, presented a picture of the world with face that was strange as to sea and land and life

upon it. Though plants with what we know commonly as flowers were just beginning to spread their mantle of fragrance over the earth, the redwood tribe was already widely distributed. The coming aristocracy of hairy animals, with brains that dominated their bodies, was slowly learning to outwit the dinosaurs and to protect its brood.

Then came the age of mammals, when the alert, hairy creatures that escaped the reptiles of earlier days ruled the world with both brawn and growing brain. I thought of the period within that time when the immediate spot on which we stood had lain beneath an ocean whose waves swept smoothly over it or crashed upon a near-by shore. From hills on which grew trees like those about us, a wash of sand and clay was then flowing to the sea, forming the mass of deposits that was to be raised up and moulded into the landscape of to-day.

Excepting for details, the living redwood

grove on which we looked was like those that flourished in past ages. The under-growth of spreading ferns could trace its relatives to even earlier time, and the zone of shadow to which they clung was the continuation of a moving region of shade that reached back not for epochs simply but for eons.

As on a journey when it is to-day New York, yesterday Washington, to-morrow Boston, in speaking suddenly you hesitate a moment to be certain whether it is Washington, New York, or Boston in which you find yourself, so in this swift flight of thought I almost questioned whether it might not be a wood of early time that spread itself before me. Walking toward the deeper shadows, which obscured such features as may distinguish vegetation of the present from that of the past, it seemed almost that one should search in the ferns for the moving neck of a dinosaur, or in the trees for slender wings of a flying reptile.

My associates were interested in the relation of this little world of life in which we stood to the geological past out of which it had grown. They asked why I might not expect to see a descendant of dinosaurs among trees that have come down to us with such close resemblance to those of ancient times.

I framed words of a reply, to the effect that probably animals change more rapidly than plants, as their structure is more complex and responds more quickly to variation of its surroundings. As I began to speak, looking with all the others into the narrow lane beyond, I saw clinging to the shaft of a great redwood an uncanny shape with lifted head, and tail that wrapped about the tree. Instead of the carefully stated philosophic answer, I replied: "I have never seen a dinosaur alive—unless I see one now."

The grotesque form upon the tree was only a "burl," an irregular growth frequently developed on the redwood, and treasured for

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the rare beauty of its wood. But often as I see them, hanging like ancient monsters where shadows give them changing form and countenance, my thought leaps over intervening ages to a time when about the ancestral redwood groves there strayed fantastic reptile generations, that in their day were lords of all creation.

With whatever turn of fancy one views this forest, it must always be recognized as a living link in an epic of history. No one who knows the outlines of its story can look down the long vistas, between gigantic columns, with the mystery of their changing shadows beyond, without feeling that he has seen through a window into the deeper reaches of time, and has come to fuller understanding of the stream of life as it is followed through the years.

If the wilderness of the inner forest lure you to explore its depths, in a jungle of

brakes and sword-ferns you may clamber over stems of redwoods piled in criss-cross. Magnificent even in their dissolution these prostrate giants, lying rank on rank, stretch back the generations of the wood to centuries not reached by its most ancient living trees.

Among these deeper shades, in turning toward the world outside, you see the narrowing vistas ending not in shadow but in light. A flood of radiance sweeps against the vault above, penetrating here and there to give its living touch.

Looking through crowded tree-tops, there is a glory in the forest that otherwise might remain unknown. The summits lift themselves to heights at which the voice of the wind in their branches is hushed by distance, and the delicacy of the topmost fronds seems refined to lace-like texture. Moving gently, the foliage touches across the openings, producing continuous variation of the light that

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streams or filters in. Beyond is the infinitely changing sky, a glowing sapphire through interlocking branches at midday; or with indescribably delicate tints if one sees it when level rays of morning or evening sun sweep over.

Standing in this field of shadow, among living relics of distant ages, in looking out you seem to turn from the clear story of a moving past to see the future rising from it through the miracle of never-failing light—the light that in unnumbered eons has poured down to mingle with the clouds of verdure, and build itself into the unfolding life and beauty of the forest.

CHAPTER V

AN ABYSS IN TIME

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IN any effort to interpret the story of life as it runs through the ages it is important to have a background of time against which to project the movement of events. If one attempts to form such a conception, it is found commonly that the materials from which it might be derived are difficult to assemble. While there are many aspects of nature in which succession, relative position, and movement illustrate the basic principles of history, it happens rarely that we see the elements of a series of incidents so situated that the evidence of continuity is clearly expressed.

The almost incomprehensible reaches of astronomy give us measures of space and time which, through their relation to each other, present a stupendous picture. But in

general, in this field, there are obstacles in the way of obtaining observational illustration of actual historic sequences. It is the object or the light at a given place and at a particular moment that we see, and not the complete picture of development.

In human history one may observe, as it were coincidentally, the steps in growth of a great cathedral which has been under construction through many centuries. Or in an archæological excavation we see the wreckage of successive civilizations piled in layers, one upon another, in such manner as to present the story of change and movement transmuted into a measure of time.

As the geologist views still greater series of layers or strata he sees their parts, or the long succession of events which they represent, as portions of a single picture. Even where remains of the record are only fragmentary, his trained eye arranges them in the order of their occurrence. To those with-

out this experience, a similar appreciation of the meaning of geological time and its content may be obtained in certain exceptional glimpses of the process of earth-building. The Grand Canyon of the Colorado is one such spectacle which appears to impress the meaning of its story upon all human kind.

Among factors determining the effect upon us in viewing the Colorado Canyon, the conditions controlling first sight of the region have much importance.—Commonly one comes suddenly upon the abyss. By whatever road the journey is made, it is almost the universal experience of the visitor that he travels long across what seems an almost interminable stony plain. Though an occasional mountain peak or butte rises to break the even surface, the architecture of the earth expresses itself as a broad sweeping structure formed from unmoulded masses of the level crust. The peculiar fragrance of the wilderness, and its strange quiet, lull him into ac-

ception of the panorama as a continuing stream.—And then at the rim of the Canyon, with startling abruptness, the apparently interminable picture of meadow, and forest, and broad lands comes to an end, as if the materials of creation had been lacking or some great change had taken place in the plan of nature.

Whatever else results from sudden contact with the spectacle of the Canyon, there should be no doubt concerning the deep impression made by the great magnitudes in height and depth and bulk, as by its changing garments of light that are never twice the same. It may be that for some the influence ends with this imprint. The vast majority seem moved by something great beyond definition, and rise to unconscious appreciation of the fact that what lies before them represents more than just the face of the world as it might have been left from an initial act of creation.

On the deeply notched and sculptured walls, with buttresses and pinnacles reaching out to distant buttes, one recognizes in the vari-colored layers a continuity of structure which appears to extend to the farther rim. The fracturing and splitting of minor features of the cliffs near by seem only an indication of processes involved in production of the marvellous architecture. Whatever be the influence that made these forms, the work accomplished is clearly the result of building or moulding in nature, and not a thing remaining as it were from the beginning. Regardless of what the point of view of the visitor may have been, scientist, philosopher, and the merely curious observer, all inevitably interpret what they see in terms of the idea so often stated in words of the cowboy, who is said, many years ago, to have ridden without previous knowledge or warning to the brink. His exclamation, "My God, something has happened here!" reflects the

universal sense of recognition and appreciation of power and movement in the making of the Canyon.

However far ingenuity and the imagination of the beholder may go in developing an explanation of construction or excavation at the gorge, one may not expect the untrained observer immediately to develop a theory accounting for so large a work. But the mere appreciation of this greatness, and of the evidence that something has been framed by power beyond our clear comprehension, represents an influence of much significance.

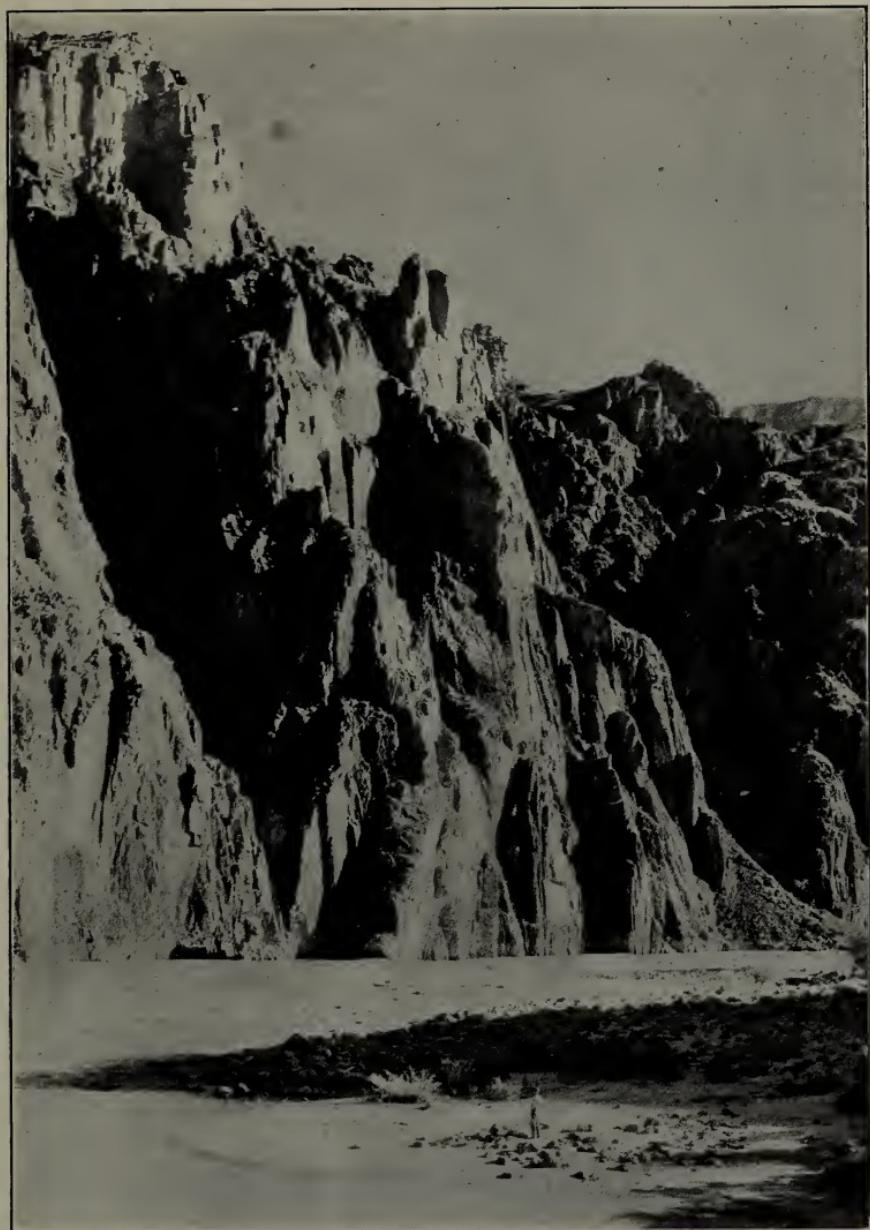
Behind the features which express size and beauty, the interest of observers is challenged by questions concerning the making of the gorge and of its walls. Whether for the investigator, or only an interested observer, the only verifiable answer to these inquiries comes from examination of the Canyon itself.—One rides down over winding trails to

view the river which forms its floor. The turbulent stream is found laden with débris ranging from discoloring mud to sand and gravel moving in its swifter current. Along the bank lie multitudes of worn pebbles and boulders, tools for the heavy work in grinding out obstructions on its bed. Whoever feels the throb of this plunging power as it tears its way, and sees the wreckage which it sweeps along, has found at least a portion of the answer to questions regarding the instrument which produced the Canyon. Fragments of rock from the walls heaped in the bars, the continuous torrent of muddy water passing by, the surging might of the stream, and the strength of it all multiplied by time, suffice to account for the major work as the river cuts its channel across the great plateau.

The story of the river and its work in excavation of the Canyon suggests in another phase an answer to the query as to how the walls were built.—The engineering problem

of the projected Boulder Dam across the Colorado River concerns itself not alone with holding behind a barrier the water that is needed. There is reckoning also with the burden of accumulating mud that would drop as a slowly thickening mantle to diminish the cubic space designed for water storage. Information as to what could happen in accumulation of débris at the dam is given in the content of the river as one sees it pass, as also in the load which it delivers when it enters the sea at the end of its journey. Visualized in terms of result rather than as mathematical calculation, one finds at the mouth of the Colorado a wide plain extending itself into the sea. The mud brought down spreads itself now here, now there, as currents shift. As a great developing feature in the landscape it presents a picture of the river as a builder.

We turn to the trail leading from river to brim. As the mule plods slowly up, the un-



From a photograph, courtesy of National Park Service.

PLATE 11. The river in the Grand Canyon, with "fragments of rock from the walls heaped in the bars."

folding panorama shows us the varying brilliance of color represented by changing types of rocks. Here are spread mounds of gravel cemented into adamantine hardness. There lies a wide stratum of sandstone once a mantle of sand. Beyond is a layer of hardened mud, with tint like the Colorado's water. In the mud are prints of a fern, and a tree washed into the accumulating layers as they formed. There in the sand are shells that belong on a seashore. Near them are tracks of a crablike creature, made as it picked its way over the débris. And above, on the summit of the wall, is a huge deposit of limestone bearing in its mass a multitude of shells and corals whose natural habitat is in the waters of a warm, clear ocean.

The Colorado shows us how a river may drop its load on the border of a sea to form a new feature in the endless remodelling of the earth's surface. The walls through which the river flows exhibit the result of a vast

work of building of this type. They are in large part mud and sand and gravel moved by rivers or pounded by the sea through a great succession of ages.

However long a time the process of cutting the present Grand Canyon may have required, its contribution to the construction of new formations may be only a minor unit in the earth's crust. On the other hand, the pile of layers forming the walls of the Canyon is spread over a broadly extended area. Far to the north and south one recognizes these formations by all their characters of color, texture, and mode of erosion. The geologist actually traces the strata from one region to another. This vast work of accumulation, as known by all available means of measurement, seems to have occupied a time ranging beyond the possibilities of our full appreciation. In spite of rigorous examination of the methods used in determining the length of this period, the estimated measure

From a photograph, courtesy National Park Service.

PLATE 12. General view of the Grand Canyon formations, including Inner Gorge with horizontal Cambrian sand layers resting upon the oldest rocks.



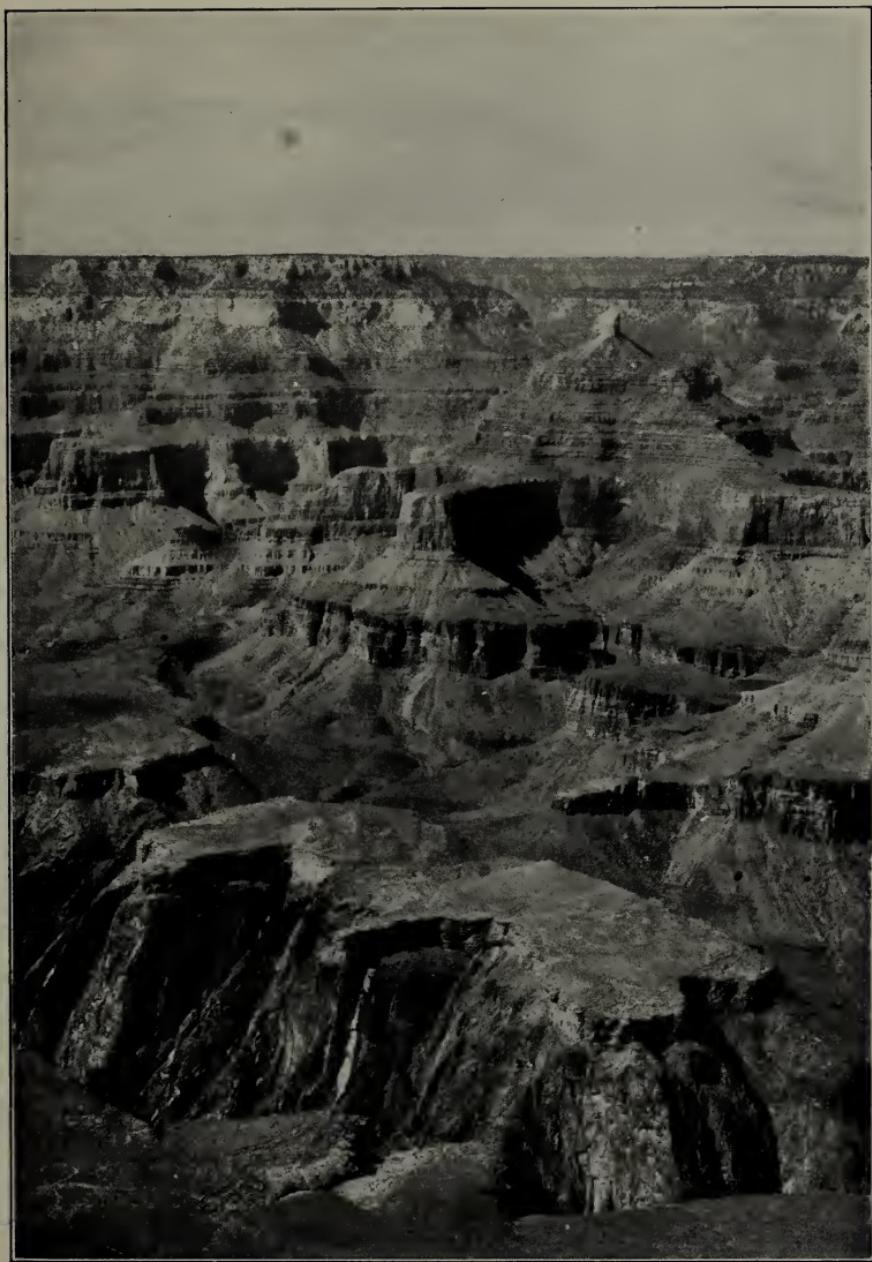
of years required to pile up the materials which form the Canyon wall reaches into the hundreds of millions.

But the records of history presented by the Canyon region are expressed only in part through the cutting of the present gorge, and in the building of the larger units of the walls. The processes of erosion and construction are shown on a stupendous scale in other ways.

If one stands on a high point near the margin of the Canyon and looks out over the pine-clad plateau, here and there isolated peaks are seen to rise above the general level. Such are Red Butte and Cedar Mountain. These two are remnants of horizontal layers of consolidated mud, sand, and gravel resting upon the uppermost strata of the Canyon rim. The same formations appear in the cliffs bordering this plateau surface far to the north. In whatever direction one goes, evidence multiplies that these deposits once ex-

tended over a wide area now traversed by the Canyon. Running water removed this mantle of rock, which was approximately as thick as the present Canyon wall is high. This occurred mainly before the Colorado sliced through the lower and older layers to make the relatively minor feature which is the Grand Canyon of to-day.

Still more impressive are the records of great events in earth history told by the lower and older portions of the Canyon cliffs.—Deep in the valley, immediately below the place from which the river is commonly viewed at El Tovar, the course of the Colorado lies in a narrow, so-called Inner Gorge. When one visits this lowest section, the rocks are found upturned and shattered in innumerable ways. The type of movement which has affected them is known by geologists to be characteristic of the greatly disturbed and folded masses which form the roots of mountains.—But the mountains of



From a photograph, courtesy Dr. F. E. Wright.

PLATE 13. Section of Grand Canyon with Inner Gorge in the foreground, showing horizontal Cambrian sands resting upon the shattered older rocks exhibiting vertical fissures filled with granite-like material.

which these rocks are considered to be the roots are no longer there.

For a great distance along the lower Canyon one sees a wide stretch of horizontal layers of consolidated sand and gravel resting upon an approximately even floor cut across the tilted and broken rocks of the Inner Gorge. These upper strata, known as the Cambrian, are not a part of the lower series. They differ from it radically in texture and structure, and are not appreciably bent or crushed. They have seen little of disturbance since the days when each sand grain or pebble in turn ceased its wanderings to settle quietly into the place it was to occupy in the building of this great structure. As one rests inquiring eyes upon the smooth roundness of the larger fragments, and realizes that rushing waters ground them to varying grades of size and form, it is clear why the mountains are no longer there.—The ancient upheaval which altered the earth's surface in this

region sharpened the movement and effect of the streams passing over it. Time and the elements transformed the mountains into flowing gravel, sand, and silt. Possibly some worked-over remnant of that mass has, in its moving to and fro, come to rest upon the remaining roots of the uplifted area. Perhaps in the new rôle, as accumulating wash from a disintegrating land, it was mainly carried to some remote area on the border of a then-existing sea.

The line that separates the ancient rocks of the Inner Gorge from the horizontal sands above occupies no space on the Canyon wall, but it presents a record of one of the most extended periods in history of the earth. The events in this region between the date when the older series of rocks was formed and the years when the first thin layers of the Cambrian sand and gravel were laid upon its eroded surface, represent as much or more of time—of building and of tearing down—as

is recorded in the whole spectacular story of the Canyon shown in the walls above this line of demarcation.

Geologists tell us that the older rocks which form the Inner Gorge could have acquired their present characters only under a covering layer greater—perhaps several times thicker—than the whole mass of strata which now rests upon them. The shattering, the alteration of mineralogical composition, and the filling of wide fissure with dikes of granitelike material, could have developed only under conditions of pressure and heat, requiring an overlying mantle of rock many thousands of feet in thickness. This great covering mass was furnished by the elevated region that has washed away. But the lifting up of the mountains and their subsequent removal represent only a part of the series of events that intervened before the sandy layers of the Cambrian came into their present position.

Exposed in limited areas at several points in the lower part of the Canyon, remnants of another ancient series of strata known as the Algonkian lie between the older rocks of the Inner Gorge and the wide-spread Cambrian. They were deposited mainly as gravel, sand, and mud upon the eroded surface of the lower rocks of the Inner Gorge. This occurred after the early mountains vanished, and before the Cambrian layers had appeared. The mass of material was not less than twelve thousand feet thick, or more than twice the height of the pile of strata in which the present Canyon is cut. Its accumulation continued through long ages, after which all but these fragments was swept away. So, when the broadly extended sand deposits of the Cambrian came to rest upon the worn surface of the older formation of the Inner Gorge, they covered and protected also this record of an enormously extended age.

Impressive as is the story of the Grand Canyon considered as a tremendous excavation in the earth's surface, we may not escape the conclusion that a much greater activity than the shaping of the Canyon itself is represented in the erosion which removed the wide-spread mantle of strata that covered the upper plateau region into which the Grand Canyon has since been cut. We know also that the mere line above the shattered rocks of the Inner Gorge carries a record of earth-building in which the elements of magnitude and power are greater than the combined work of making the present gorge and the stripping of the broad plateau above.

The influence upon every visitor who stands on the brink of the Canyon, whether it be mainly in terms of size and beauty, or only in framing the questions "how?" and "why?" means an opening of the mind to new and greater personal experience. Appreciation of what lies beyond the most obvious

aspects of the story may be slight, but those who search for an interpretation receive at least a faint suggestion of the "something that has happened."—The physical abyss impresses with its majesty and power. The matchless architecture, the colors spread in unimagined ways, the changing hues of atmosphere and sky and shadow, all bring unfailing joy.—With no less vital reality, the vision of time presents itself like the opening of a door upon the past. Perhaps even more striking than the contrast of physical grandeur of the Gorge with the gullies and canyons of our previous acquaintance, is the comparison of this great chasm of ages with the measure of passing years as we have fathomed them.

For those who go down into the Canyon to set their feet upon the strands of early time, or to lift with reverent fingers the trace of a fern that for years in untold millions has rested on the bank, there are places where

history not merely reveals itself, but for every one seems waiting to tell its story. With a sense of reality like that of the present, in standing before these ancient links in the record of the earth, we are conscious of the streaming waters that rattled and pounded the heaps of worn and battered rocks, or of lapping waves as they spread the sand upon beaches where crawling things marked the rhythm of their pace upon the floor.—And the whole long panorama represented in the Canyon wall becomes a thing of life.

But the meaning of it all is not comprised in the startling reality of the many episodes in history that one encounters, nor yet in the truth that the sequence in which we find them is the order of changes in nature. When from some commanding point one looks out over the spectacle, not merely is there apparent the true significance of each of a multitude of incidents in order, but the relation of these differing aspects of the world to each

other translates them into an expression of activity extending through time. One sees the mechanism of nature and of history as if with all its parts in operation, and compasses the great complex in a single sweep of vision.

As this abyss of time cuts down across the ages, it presents in clear perspective of one great picture the reality, the sequence, and the movement in a vast tide of events. The beginnings do not appear, but upon the high walls enough is written to illustrate the processes of change, and to show us also that the end is not in view.

CHAPTER VI

FOOTPRINTS ON THE PATH OF HISTORY

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THE strata which form the leaves of the geological book have accumulated as broad layers in which the thickness compared with the width is as in a tissue of inexpressible thinness. Each of these deposits is, as it forms, the surface of the earth. The record written on it is a natural imprint made in part by living things moving about upon the land, or on the floor of a sea, or lake, or river. Whatever the creative process may be, or however it may express itself, the winding road traced over the forming layers by successive generations is the path of life through the ages.

The fragments of the geological record found here and there over the earth have been pieced together to make a volume of stupendous proportions, although many sec-

tions are incomplete. The definite record of life in action as we know it through the ages is also scanty, but as years pass the evidence accumulates at an astounding rate. The two illustrations following may suffice to show the significance of data of this nature available to us.

The caretaker on Hermit Trail was clearing away rock from the lower end of the White Zigzag, a thousand feet below the rim of the Grand Canyon. Lifting the slabs of sandstone he noticed that they were smooth like stones of a pavement. As he uncovered a long block in widening the path, he was thinking: "Here is one which no foot of man or brute ever touched." Then his eye caught the print of a little clawed foot with toe-marks thrust deep into the sand—and then another, and another, and another, as the tracks, evenly spaced, reached across the slab. The last showed only the tip of a heel

where the overlying rock bordered the path. It occurred to him that the toes of this foot might be under the rock. Looking more closely, his eyes stepped again from print to print until they rested on the heel pointing beneath the cliff. Seizing his pick, carefully he pried up the slab above. The heel stretched forward into imprints of toes, and just beyond it another heel marked a continuing trail leading under the wall.

Leaning against his pick-handle, the trail-maker looked up at the cliff—across the thousand feet of rock, layer upon layer, that built the wall above. He turned and looked out toward the Canyon, cut nearly a mile into the earth since the topmost rock stratum was finished, and said to himself: "It was sure feet that made them tracks, but it's a long while since they passed this way."

Mike and Bert, who had told me this story, promised to point out the spot where the trail with ancient footprints marked in solid

rock crossed the White Zigzag on the Canyon wall. Next morning found us dropping over the rim at Hermit Rest. Passing down into the gorge, we crossed a great thickness of limestone layers, filled in places with shells of animals that lived in the sea in which these deposits formed and had left their lime-bearing remains to make a part of the accumulating mass. Lower in the Canyon the rocks changed to sandstone, spread originally as even sand layers, but hardened during the lapse of ages to plates and slabs of stone now called the Coconino sands. Where strata of different texture were separated we could see the surface of each bed of sand exactly as it was before succeeding deposits were laid upon it.

Resting on the way for a moment, in the shade of a projecting rock, we were talking of the object of our excursion when Bert pointed to the footprints of a wildcat which had followed the path some hours before us.



From a photograph, considerably reduced, courtesy National Park Service.

PLATE 14. Footprints on ancient sand layers which form a part of the walls of the Grand Canyon.

Then we hurried on down the slope, following the trail which the big cat had marked in the dust.

In crossing the strata of the lower Zigzag, every exposed surface of ancient sand layers was inspected with care until Bert, somewhat in advance of other members of the party, waved his arms in indication of success in his search. We hurried to the spot. At this point the trail was cut into the rock. Below it was a mass of loose blocks, partly formed by natural disintegration of the cliff and partly torn out in cutting the path. On the upper side, undisturbed sandstone was exposed in a succession of thin layers readily pulled apart.

Bert pointed to a wide slab extending into the wall. Bending eagerly to examine it, we saw on the fine sand of its surface marks of feet walking from the dust-sprinkled floor of the trail over the face of the rock and disappearing beneath the layers above. The four

feet had been set down daintily and yet firmly—the sharp toes cut deeply into the sand. The spread or straddle of the double row of footprints indicated limbs set wide apart, as in salamander-like forms whose bones are found in rocks of the age in which the Coconino sand was deposited. The tracks were not those of any animal known in the life of Arizona to-day, but their clear imprint, and the regular spacing of footsteps crossing the surface, left no room for doubt that we looked upon the trail of a creature that moved alive over this sand.

Looking back to the spot where the slab with ancient footprints crossed the path, I noticed the touch of a wildcat's foot showing faintly in the dust. Kneeling, the rock was wiped with my hand, and then with closed eyes all remaining particles were blown away. When the air cleared, I looked again. There, where the cat had left its imprint in a film of dust a few hours earlier, were tracks of

little feet marked on the sand, now hardened to stone, and between them in the same rock was the sharp cut of a mule shoe.

No one of us had seen the cat quietly tip-toe by in early morning, nor had we watched the mule with its tourist passenger tramp circumspectly down the slope, but we needed no further evidence to assure us of their recent passing. We knew also that even the venerable cliffs arising around us could not have viewed the making of the footprints in the Coconino sand. We realized that the Canyon with all its majestic expression of antiquity and stability must have been still in the future of creation when the seconds and minutes of that early time were marked off by rhythmic movement of the feet which made this earlier track. And yet, as we looked upon the two records, the prints on ancient sands, preserved through time beyond human understanding, were not less real than were the traces of the cat's light touch made

in the morning of the day on which we found them.

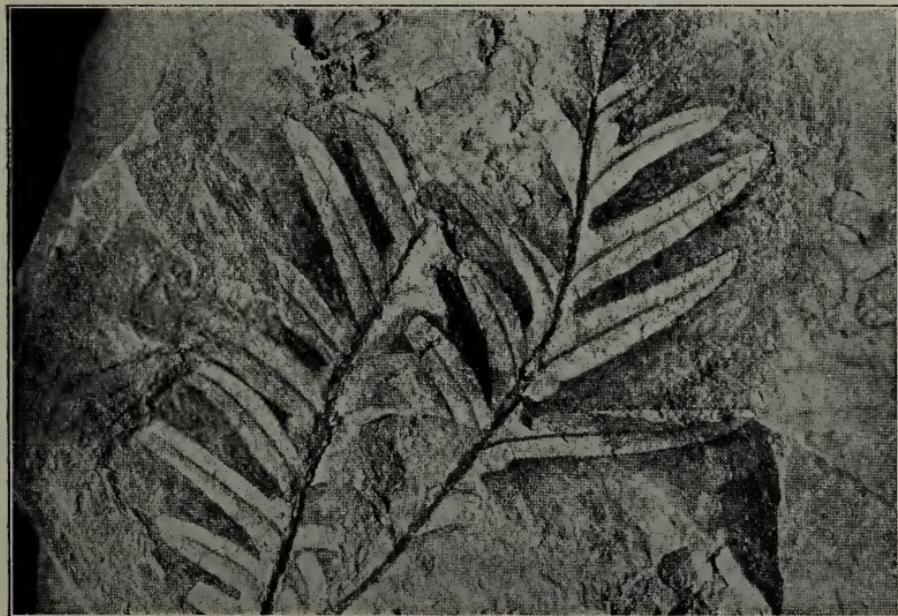
Here was the crossing of two trails. Each was clear and unmistakable; one made that day, the other held unchanged as by a miracle from time so remote that we could only vaguely appreciate the magnitude of intervening ages.

Down into the gulf of the Canyon we had followed the tracks of wildcat and mule zig-zagging over uncovered edges of strata piled upon the surface marked by the older trail. Each successive layer of the multitude traversed contained a record of events that marked years leading back to the day of the Coconino creature. Then, as we halted where this modern trail crossed that made by the ancient footprints, we had seen the path on which we came reach down across still greater depths of strata in the gorge below. And we knew that this further volume of history extended into periods that already



From a photograph by the author.

Locality at which fossil footprints were found at Grand Canyon.



From a photograph, somewhat reduced, courtesy of Dr. David White.

PLATE 15. Impression of a fern, from ancient strata of Grand Canyon.

represented a distant past at the time these earlier imprints were being made.

Looking out over the gorge with its wonderful records, we were impressed beyond measure by the effects of the power that opened the earth to make this chasm, and by evidence of vast forces involved in building and moulding the world which were everywhere laid bare on the walls. It seemed that, with all its overpowering grandeur, the Canyon could tell us nothing so impressive as the story of making the earth, opened to view along this path crossing from to-day to yesterday. But when, in the midst of evidence of vast changes in the face of nature, we saw the touch of moving feet, still fresh and clear upon the sand, the ancient earth with its unstable continents and shifting seas was transformed from a theatre for play of lifeless forces to the scene of eons of growth and struggle in a world of living things. Expressing with surpassing vividness the reality of

beings that walked about on feet like those of man and beast, these prints upon the shore brought clear realization that in this early time life resembling ours was making its way and meeting the difficulties of a changing world. This living story of the creature that walked the Coconino Trail made us see the majesty and beauty of the Canyon as a background, over which there moved a picture of that greatest of all dramas—the story of life.

After a morning spent in learning something of the account of ancient life given in this record of the rocks, we stopped for rest and luncheon under a juniper on a steep slope near the trail. Mike sat looking out over the Canyon where we could see the Coconino sandstone marked clearly in its place among the strata on the opposite wall. Then, turning quickly, he asked me how far the makers of the footprints had probably travelled. I said: "Do you mean horizontally or vertically? We have here a veritable moving

picture of them as they passed. We cannot follow them as individuals to the journey's end, but we know that generation after generation of their descendants saw layer built upon layer above the sand in which these tracks were buried. As the pile grew they moved upward over the surface of changing landscapes formed upon it. With passing years a sea came in to replace the land, but the procession kept on its way over other steps that the gorge does not open to view."

We looked again at the ladders and stairways formed by strata in the Canyon wall rising around and above us. "Well," said the youngster of our party, "it was the game to keep moving and climb as fast as the stair was built."

As I think back to the thrill of this experience on the Hermit Trail, there is impressed upon me with increasing emphasis the wonder and beauty of the story one reads along the way. But I realize that with all the joy

of discovery we only begin to understand the meaning of what we see.

Standing on the very sands in which these traces of moving feet have remained so long to tell their story, we look up to the cliffs and out over the Canyon, seeing as reality what could have been only a vision of the future when the ancient creature pressed its feet upon the same surface. Then we turn and read the story of that still greater past opened to view in the record of the gorge below. And we ask whether, with all our knowledge of this movement of the world through time, we may not learn to build upon the past—to build, as well as wait to climb the stairways when they rise before us.

Near Carson City, Nevada, is a prison yard known over the world as exhibiting a unique chapter in the story of ancient life. This site was once a quarry from which has been obtained much of the material used in construc-

tion of important buildings in the city. As the sandstone slabs were taken out, the yard was extended over a broad floor of undisturbed rock below. On one side it was bordered by the steep cliff of the quarry, and on the other by a man-made wall.

In quarrying the building stone, from time to time remains of animals and plants were found buried in the rock. Such were the shells of clams and snails, along with bones of horse and elephant. And then, on the layer forming the floor where excavation was discontinued there appeared the prints of many feet that had left their traces before the strata above were deposited.

The footprints were largely those of animals we know—tracks of a drove of horses swung up to the cliff and disappeared beneath the rock above. A wolf walked in another direction; many prints of feet of birds, a large cat, and an elephant with tracks more than twenty inches across, also came to view

as the rock was stripped away. And among others there were numerous tramped-in traces of a large, heavy animal, into whose tracks the perfectly preserved foot bones of a great extinct sloth-like animal are found to fit with exactness.

A tunnel was cut to follow the footprints of the elephant, and one may go beneath the cliff to see the trail that was made when the clayey surface was a part of the face of the landscape, and the rocks above had yet to be transported as sand to build the strata composing the wall above.

As one comes from the tunnel there is a feeling that the past is left beneath the rocks. But across the court in the solid stone of the floor we recognize other prints of feet such as we have seen by the roadside just outside the prison wall. They are the evidence of life as we know it to-day. When they pass beneath the cliff we seem to see the living present reach back into a distant past that also lives.

As men move to and fro across the yard on business with immediate human import, one realizes that however much this strange occurrence of ancient relics may excite curiosity and scientific speculation, its ultimate value must be estimated in terms of human life. There is no better illustration of my meaning than that given by the story on the floor of Carson Prison.

Of all possibilities in the world, a prison provides the situation in which meditation on the past might be expected to have largest place.—I often wonder whether at Carson Prison Yard the men who have constantly before them this almost miraculous preservation of evidence of what happened in a remote age, consider it a suggestion that no time is too long after an event for the uncovering of what has happened. Or does it indicate to them that not years, nor the elements, nor anything, may take away the influence of a mark once made? Or is the story to them as

THE LIVING PAST

I would see it—that is, the evidence that in this changing world in which we live there is always hope that something better may be built?

CHAPTER VII

ARE THE DAYS OF CREATION ENDED?

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THE general unsettling of human relations which came as a consequence of the World War raised wide questioning as to the future of civilization and the ultimate fate of mankind. Evidences of breaking down in so much that had appeared fixed in social organization naturally caused review of the guarantees of orderliness and progress to which we had been accustomed. In consideration of such questions we have naturally come to inquire as to the expectation of continuity not only in civilization, but in the process of creation so marvellously expressed in the history of the world up to this time.

Many practical persons assume that no special reason exists for concern with anything that moves so slowly that it does not

make itself felt in a measurable way in the special interests of a single generation. But we must remember that society is a continuing thing, not limited by generations. It is interested in its own future, and whatever touches this concerns also the immediate personal relations of all individuals involved. There is certain to be wide difference between the psychology of persons in a world expecting progress as compared with that of one anticipating stagnation or decay. This will be true regardless of immediacy of either progress or disintegration.

There is nothing contributing to the support of our lives in a spiritual sense that seems so clearly indispensable as that which makes us look forward to continuing growth or improvement. It is difficult to believe that human life could exist without such expectation. Whatever concerns the basis of this belief is vital.

Nearly every people with a history suf-

ficiently long to permit accumulation of results from mature thinking has set down some form of expression of its views concerning the meaning of its own creation. In a great percentage of these statements the central thought is mainly that we have not always existed, and must therefore have been brought into being by forces beyond human control. It is not improbable that in certain of these stories, as in those of India and Egypt, there is more than a mere statement of the fact that we were created. There are not only suggestions as to the steps by which our environment was prepared, but stages in the development of man himself seem to have been considered.

With advance in interpretation of nature by modern philosophic science, we have come to learn an extraordinary story of the past of our earth and its inhabitants. While science has not attempted an explanation of ultimate origins, it has gone far to show how

nature and man developed to their present state.

The astronomer and geologist have left us no room for doubt regarding the vast extent of time in which the world has existed; the geologist has given us a moving picture of our earth through a long series of stages preceding that in which we know it to-day; the palæontologist has made us acquainted with innumerable changes in life of the earth leading up to appearance of man and then on to the present. The biologist has come to understand something of processes by which life produces life, and of principles which control production not merely of new individuals but of new kinds of living things as well.

As I see the meaning of these advances, the great contribution through science is not merely in the fact that we learn of our having been created—we knew that already—nor in the idea that we have a history, as everybody suspected that also—nor yet in

the evidence that we have come into being through a long series of stage of growth which had not been known to us. Rather does the value of scientific contribution, in the historical sense, reside in the evidence which it furnishes that the movement shown in nature through vast ages makes known in some measure the character of the thing with which we deal. Science expresses through history both the idea of unity in nature and its laws, and of continuity in their operation. It indicates that what we see does not merely concern man and the present day, but is something larger than present or past alone.

The greater part of the history of our earth is a matter for consideration of the astronomer. Geology deals only with the more recent events. In its relation to the extended reaches of astronomy, geological history shrinks to a relatively minute stretch in the field of time.

By methods of measurement now used it is shown that our solar system is a mere speck in that great assemblage of stars which we call the Milky Way. We begin to form a conception of the size of this region when we realize that it takes light, travelling at the rate of one hundred and eighty-six thousand miles per second, a time estimated at more than one hundred thousand years, to cross this star field.

But the astronomer does not permit us to rest with these figures as finality in measurement of space or time. The Milky Way in which we live is a unit field of stars hanging in space, and there are other bodies which resemble it in the region outside this star system. The spiral nebulæ lie beyond the limits of our special universe. Many of these nebulæ seem to represent other universes comparable to our Milky Way. Perhaps they attain dimensions even greater than in our system, but are so far removed that only the

light-gathering power of a great telescope makes them visible. The distance of such bodies is almost beyond our power to appreciate. The element of time involved in this story, as we read it, is beyond adequate expression, but this question of time and space has its intimate bearing upon the problem of the continuity of conditions which make life possible upon this earth.

The record of the rocks, from which we read geological history, does not cover more than a small portion of the past of this planet. We find that the most ancient strata observed are, by reason of their great age, broken, shattered, and changed into new mineral combinations by pressure, heat, and other forces. These oldest known rocks rest upon a basement which was once molten material and has come into its present position since the rocks now above it were formed. The oldest strata thus far examined rested once upon a foundation which represented

a still earlier time. That basement is now destroyed or replaced by melted rocks of later date. It thus appears that we have lost the beginnings of our geological record, and there is reason to believe that what is lost may represent a period as long as that covered by all of the strata that remain.

What we have left of the record is not an unimportant story. The strata available when carefully pieced together give a total thickness of more than fifty miles. Calculated by various methods, the more conservative estimates of the time required for accumulation of this pile are now measured in hundreds of millions of years, with the tendency of leading geologists toward lengthening the time to cover at least one thousand million years.

There is much evidence in the rocks indicating the conditions of atmosphere and temperature under which the successive strata of the geological record were deposited.

It has been possible to form a fairly clear picture of the many climatic variations to which the earth has been subjected within the range of our available record. At one time it was believed that the climate of early geological periods was relatively very warm, and that as ages passed the earth cooled down to a condition illustrated by the glacial epoch immediately preceding the present geological stage.

The most recent studies have shown that in the known period of earth history there is no evidence of very great change in climatic conditions of the earth as a whole. There are records of many glacial periods, some even in the earlier ages. There have been many minor changes from warm to cool periods, and the reverse; but, in general, the physical conditions obtaining on the earth one hundred million or more years ago were not materially different from those of the world, as a whole, to-day. This statement should not

be interpreted to mean that minor changes of climate have not taken place within this vast period. There have been almost continuous climatic fluctuations, but the extreme range has been within very narrow limits. So closely has this range been restricted that in terms of the changes expressed in the physical evolution of a star or planet the difference between climate of the earliest geological stages we know on the earth and that of the present is almost negligible. This means that in terms of evolution of heavenly bodies, the vast geological history of the earth now open for our inspection is probably only a brief span compared with the preceding astronomical and geological ages of which we have no record—and that, judging by history as we know it, there is no reason why conditions like those which have obtained here for long ages should not continue, without material alteration, for a further period comparable to the time of which we have knowledge.

It was for a long time customary in physics and in astronomy to look upon our solar system as a mechanism of the type of a clock rapidly running down. The sun has been assumed to be growing cold. Inasmuch as the earth is dependent for its heat upon the sun, many have looked forward to a dead earth, the disappearance of life, extinction of man, and many other natural consequences following in the train of this physical change. Recently, however, it has been shown that the life period of the sun may be enormously lengthened by the breaking down of matter into radiant energy. This, it is held, will lengthen the life of the sun vastly beyond what was assumed to be its maximum possible age. By this change there is opened the possibility of the extension of conditions of temperature which govern life upon the earth for a period of great extent.

Knowing that present conditions of atmosphere and temperature reach back to

earliest known geological records, it is not surprising that with continuing search the palaeontologist and geologist have found evidences of varied life in earlier and still earlier strata, until there are now known in the older groups of rocks sufficiently well-preserved traces to tell us of living things which existed in that early time.

Many of the most ancient rocks have been so crushed or otherwise altered that they have lost their original character entirely. Such strata could not be expected to contain remains of animals or plants, even if they were entombed in them at the time these rocks were forming as layers of mud, sand, gravel, or other deposits accumulating naturally in ancient seas, lakes, and rivers.

Remains of life from the older rocks are not limited to the simplest forms found on the earth, but are of many kinds. If the evolution theory presents a true picture of history of life, the earliest types should be the sim-

plest stage, from which the more complicated forms would later be developed. It has been assumed by some that as this ancient life is fairly advanced and differentiated it furnishes definite evidence contradictory to the theory of evolution; but when we remember that the earlier part of our geological record is absent because it was destroyed, we recognize the earliest known stages of life as just what we should expect to find under known conditions.

We do not know when life appeared upon earth. Presumption favors the view that we shall never find the portion of the geological record which might contain this evidence. If existence of life on this planet is governed by presence of physical conditions in a general way comparable to those which now obtain, living things may have been present here in time preceding our first record, for a period as long as, or longer than, the entire space of known geological history.

Just as we realize that while our total geological record is only a part of what might be known, but is none the less a vastly long period measured in terms of human history, we should understand that, though we do not see the beginning of life history, the record now open to us is actually of great extent and tells much of the nature and movement of life.

Somewhat in the manner in which physical conditions on the earth show continuous variation, so our record indicates that life changed continually through geological time. Each stage of the geological period is characterized by remains of animals and plants similar to and yet mainly differing from those of immediately preceding and following ages. While fluctuation in physical conditions between the beginning and end of the record available has not resulted in marked deviation from an original standard, we find that in history of life the changes

are in general cumulative modifications in definite directions. The fossil remains found in rocks of each stage of the record are not merely different from those representing life of other periods, but they form series in which the representatives from earlier time are generally of less complicated structure. In terms of the nervous system, the older forms were less intelligent.

The facts of occurrence or succession of remains of living forms indicate that they are in the order in which they would appear if the life represented in the strata formed in each successive period were descended from that of the preceding period, but had been modified away from its parent stock in the process of descent. Thus we have the suggestion that the whole succession is connected through blood relationship.

This trend of movement or of growth we see operating continuously from the time life appears in the geological record up to the

present. The movement comes to be recognized so clearly as a habit of nature that we are surprised, and seek for explanation if an apparent exception appears.

The question as to what made organisms pass through this long series of changes represented in the geological record must be answered by the biologist; as also the inquiry as to how these modifications are related to variation in physical conditions of the earth which has formed their environment during this period of change. Biology has made great advance in those studies of variation of characters of living types of animals and plants which will be necessary in approaching the solution of these problems. We know, first of all, that we must account for the origin of individuals and of races of living things by their development out of preceding or ancestral types. While there may be foundation for belief in generation of the simplest forms of biological mechanism from things which

seem to be non-living, there is no ground for belief in the origin of any higher form of life except by birth from other life.

Development of the individual has been the subject of exhaustive study covering processes of reproduction and growth, until we begin now to understand the meaning of change from one generation to the next. The problem of how a new kind or variety or species of life comes to be derived from another we find involved in study of the mechanism by which individuals originate, and also the manner in which the individual relates itself to its environment. One group of biologists holds that in the origin of new forms the major emphasis is to be placed upon the mechanism of inheritance; another that environmental influence is the factor of major importance. Others consider that each of these factors is important; heredity being the gravitational element which holds nature steady; environment, through a wide

range of complicated relations, tending to make the individual and its descendants accommodate themselves to variation in their surroundings.

Regardless of the particular theory used in explanation, there is reason to believe that the influences governing known development of life through the ages are related in part to variation in physical conditions at the same time in different places. Moreover, we know that the crust of the earth has been in almost constant movement through geological time. Mountains have grown up and been worn down. Great land areas were lowered and became groups of islands, or disappeared entirely beneath the sea. At other points uplift of the crust raised the sea-floor and formed land. These fluctuations in the position of the earth's crust, together with the influence of changes in climate, have forced life into almost constant adjustment, either to new conditions in the same place,

or to similar conditions in different places, and have thus been either the cause or occasion of continuing migration and continuing development of new forms of life.

The relationships which we find expressed in the history of life indicate that, given a mechanism of the type which life represents, we may expect it to vary, change, progress in an environment such as that furnished by our earth. It would probably require intervention not unlike that which would be implied in the halting of gravitation to stop this continuing change if an approximation to past variation in physical conditions continues.

Let us now recall that vast as the period seems during which life has existed on the earth it may be only a fragment of history geologically, and is presumably a mere moment measured in our astronomical history. We note that variation of physical conditions during this period has been within extremely

narrow limits. Unless some new element is introduced to influence earth history, what we now know of factors governing the life period of the sun, which is the source of heat and light on the earth, makes it difficult for us to imagine conditions changing so radically as to prevent existence of life on the earth for a long period to come. Given continuity of present conditions we should assume that variation and evolution or forward movement will go on for yet a very long time.

This growth or movement of life is characterized at the same time by instability and by progress. It is a process of creation, in that it brings into being types that have not existed before. In the biological sense it is a continuing process which should proceed without interruption unless some new force is introduced to arrest it.

When we consider the place of the human group in this world of life on the earth we

realize that man is not a creature of the present day alone, but that he comes out of the remote past, and his history merges into that of the sabre-tooth tiger and cave-bear. Man evidently came into being as a part of the world of living things by a process of creation which did not differ materially from that by which other organic types arose. He appeared at the moment in geological time when we would expect him if he is a product of growth out of a lower substratum of life. His course of history follows laws of distribution, variation, and progress illustrated by abundant examples in the whole life world.

From stage to stage, through a period which seems vast measured in terms of so-called human history, we find the man type changing its form and approximating more and more closely to the specific kinds of human beings of the present.

To-day we see man distributed over the

whole earth, varying widely in physical characters in different parts of his habitat. He shows a relation of his physical differences to variation of environment in a manner similar to that exhibited by the wide range of animals and plants known so well through our studies of distribution, variation, and evolution of organisms in past periods.

At the present rate of progress it seems quite certain that within a few centuries the human race will have almost complete control of the biological world. Man will take what he wishes. He will determine what plants and animals he desires to retain, and what may be eliminated. Much of the power of nature will be harnessed and directed to his use.

When we consider the relation of future biological or creative evolution to human beings we find a number of leading students inclined to believe that further development of man will be shifted entirely from physi-

cal to so-called social evolution, involving development of institutions with accumulation and organization of knowledge. This social development is characterized by its relation to a train of continuing experience. Individuals disappear but the body of knowledge and the consciousness of society persist. In this phase of evolution discovery and research contribute by bringing in new knowledge, science and learning serve to organize information, business makes knowledge effective, education carries it from one man to another or from one generation to the next. The body of knowledge involved in the social organism may grow indefinitely. There seems almost no limit to the distance which humanity may go in increasing acquaintance of its environment, as well as in understanding the individual and social characters of human beings.

There is, perhaps, a limit to which knowledge may be used by man. While we have in

a certain sense a social consciousness, a mob mind, and a racial mind, in the last analysis, expression of all these things must come through the individual. We must not forget that individually we are sharply restricted in extent of our experience, in possibilities of accumulation of knowledge and wisdom, and in our capacity to use the great stores of information even when secured.

The future of mankind in the social sense depends then not alone upon our capacity to accumulate and to organize. Ultimately, in handling our greatest and most critical affairs we must depend upon the capacity of individuals to understand and to utilize the materials thus brought together. The success of democracy depends in large measure upon selection of individuals with adequate ability for performance of great tasks. Our success depends also upon the possibility of having the social world so organized and trained that each element in the complicated

machinery will keep understandingly to fulfilment of its duties, so that the whole mechanism may operate in orderly fashion. It is probable that we could learn to handle this stupendous machine provided all the parts could be kept in perfect adjustment. But not only do individuals have limited capacity, they have also emotions, and desire for individuality. Independence is one of the most marked qualities of human beings. These are factors which bring almost infinitely complex elements of disturbance.

To the difficulties mentioned there must be added a further limitation arising from the fact that generations of people are replaced by others with great rapidity. No sooner have we trained an individual or a group to particular habits of conduct than another generation comes upon the scene and the educational processes must be repeated. These conditions relating to the place of the individual in the complex of society mean

that, not only must we know how to control the machine, but the individuals who operate it must have extraordinary knowledge and experience, making it possible for them to bring about continuous readjustment of the parts while normal changes are in progress.

With continuing increase of knowledge and of complication in our social machinery, a limit is approached beyond which it will be extremely difficult to handle forces which we organize, unless there be opened also the possibility of development of the individual in the sense of enlarging his capacity for knowledge and ability to use it.

The limitations put upon social evolution by reason of restricted capacity of the individual make us consider seriously the question of further evolution of man in the sense of development of body and especially of brain. For use in such study we must have the best possible understanding of the laws which have controlled biological evolution in gen-

eral through past eons. This type of progress depends upon our securing a fuller understanding of all questions concerning human variation and race differentiation, and of relation between purely biological factors and social factors.

We have learned that, through five hundred million years or more of history of plants and animals, organisms of this world have adjusted themselves to varying conditions, and forward movement has taken place through the ages. The student of living things has found, combined with stability of hereditary tendencies, the operation of factors which determine that no two individuals shall be alike and no two generations alike. Our knowledge of life in the widest sense indicates that, in a world such as this, the tendency to variation and to progress is as near to being truly characteristic of life as are any qualities which we might consider distinctive of that state of being.

We have then to inquire whether by reason of man's intelligence, because of the fact that he has come to know and control nature, because he has attained most nearly to godlike characters, he will be the only organism in the universe unable to take advantage of the laws by which the organic world has steadily advanced.

It is true, as many have suggested, that with his increase in knowledge man encounters new dangers through widening opportunity for evil, which places obstacles in the way of his progress. Frequently he handles great forces of nature, or directs organized human emotions with little knowledge of results to come. The largest danger lies, however, not in new knowledge of nature, but in man's ignorance regarding himself—both as an individual and in the mass.

We must be clear that increase in knowledge offers not merely possibility of evil. At the same time it opens greater opportunity

for good, together with better ability to choose between the evil and the good. We should have no sympathy with the suggestion that civilization is a disease which halts evolution and leads us to destruction. It is the natural development of human life, following discovery and organization of knowledge.

Civilization need not destroy us. If we suffer it will be because we refuse to recognize that man is himself the greatest of all subjects for study, and that we know relatively less of his nature and capabilities than of many aspects of the natural world toward which our investigations have been directed. We need for the safeguard of our future more knowledge, better organization, better education, and especially the results of wider and deeper research on the nature and personal values of human beings than has yet been accomplished. When this is done, we may trust man in his use of the tremendous opportunity for creative work in the advancement of the race.

And, to return to the thesis of this chapter, we need for man that opportunity for forward movement or evolution in his physical being which may enable him, not only to add to his accumulated information, but to increase the possibility of using his knowledge to full advantage.

There is, I believe, reason to expect continuation on the earth of those conditions physical and biological which have made evolution possible in the past. In this environment the life world should remain flexible and progressive. Man will be a controlling or guiding factor in the evolution of animals and plants. It is for me impossible to believe that, with the great scheme of development of this universe carried on through almost endless time, we can imagine evolution halting because of the possibility of destruction or disintegration due to the advance of intelligence in the created. We are safe in assuming that in addition to the tendency of organisms

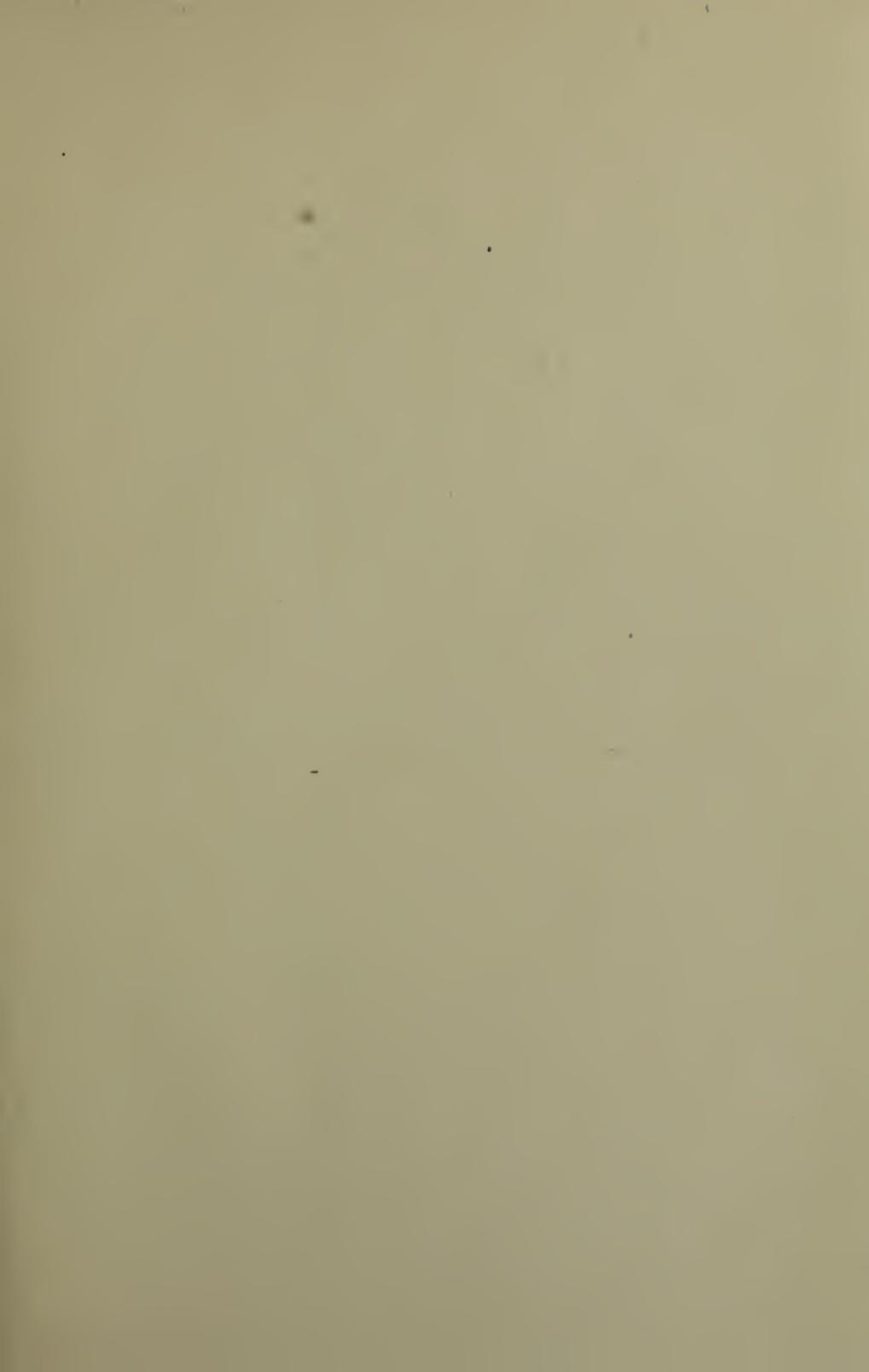
to vary and to progress we shall have the understanding and guiding mind of man to take advantage for himself, as well as for other living things, of the laws which he will come to know, and which he will wish to use in his striving toward the goal of betterment.

So, as we read the history of life and of man, and appreciate the dangers of our advance in learning and in civilization, we may realize that we are taking for our use that dangerous fruit from the tree of knowledge, and may question whether we can bear the consequence of coming to view the world as gods. At such a time it is proper that we turn in reverential inquiry to view the record of the past through which creation has revealed itself. There we find a history open for our information. It tells us of forward movement of the world from which we have grown, and in which we are a part. What greater gift could we receive than to learn

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through the evidence there presented that the conditions which have governed the creative process are essentially those which operate to-day and should be expected to continue; that whatever power has existed behind nature in the past expresses itself to-day, keeping the world a place that may be ever new, and justifying faith that progress will extend itself into the future?





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